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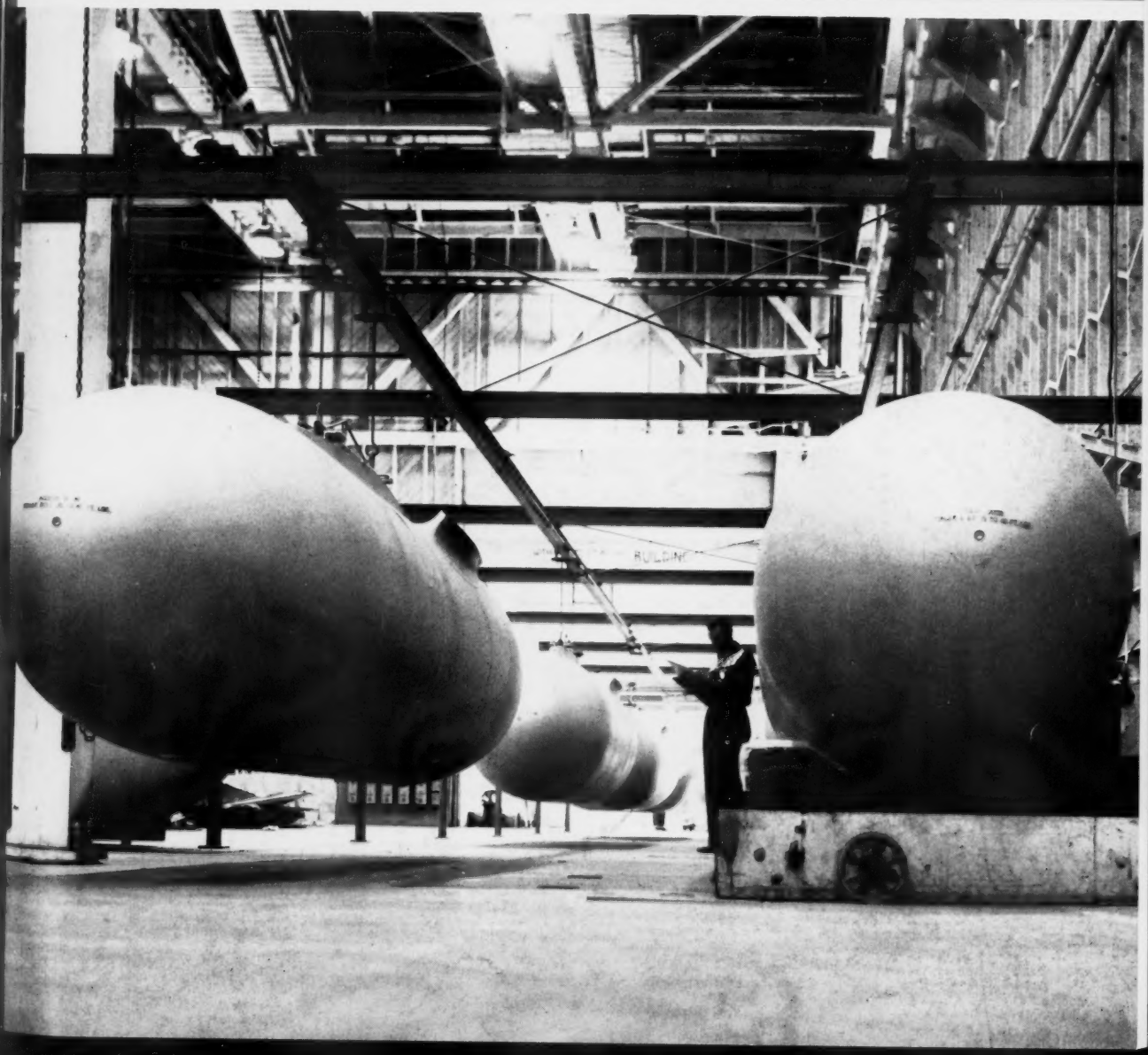
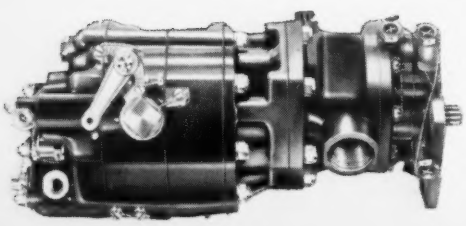
# AERONAUTICAL ENGINEERING REVIEW

INSTITUTE OF THE AERONAUTICAL SCIENCES

MARCH 1952



**Chance-Vought's new NAVY F7U is powered by the WESTINGHOUSE J-34 Jet Engine. Turbine Control by HOLLEY.**



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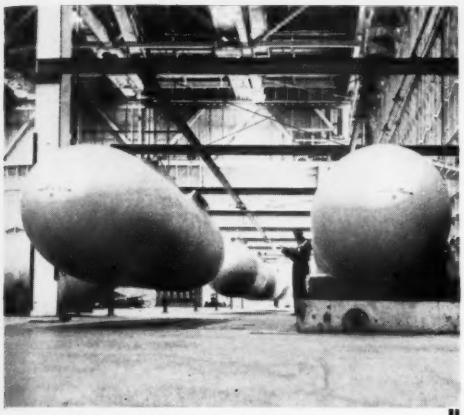

Cover—Believed to be the largest external fuel tanks ever produced for aircraft, these torpedo-like structures are being built in substantial quantities by Ryan Aeronautical Corporation with huge electrical seam welding machines.


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# AERONAUTICAL ENGINEERING REVIEW


**Vol. 11** **MARCH, 1952** **No. 3**


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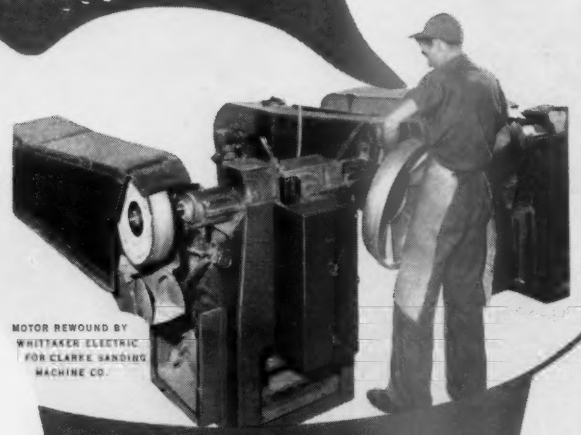
*Published Monthly by the Institute of the Aeronautical Sciences, Inc.*

# more muscles for motors





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# I. A. S. News

*A Record of People and Events of Interest to Institute Members*

# Comments on Twentieth Annual Meeting

## *Registration for Technical Sessions Hits All-Time High. Capacity Crowd at Honors Night Dinner. W. F. Durand Aeronautical Museum Established in West Coast Headquarters.*

THE TWENTIETH ANNUAL MEETING of the Institute of the Aeronautical Sciences drew the largest group of aeronautical engineers and scientists yet to have attended any I.A.S. function. The registration for the entire 5 days of technical sessions reached an all-time high of 1,335 representatives from all parts of the globe and from every known field of the aeronautical sciences.

▸ **Honors Night Dinner**—A capacity crowd of approximately 1,200 diners gathered in the Grand Ballroom of New York's Hotel Astor on the evening of January 28 for the annual Honors Night Dinner. The presentation of the I.A.S. Fellowships and the Jeffries, Losey, Reed, and Sperry awards was the highpoint of the evening. The outgoing I.A.S. President, Rear Adm. L. B. Richardson, U.S.N. (Ret.), Senior Vice-President, Electric Boat Company, presented the awards.

Information on the two new I.A.S. Honorary Fellows, L. R. Grumman and J. H. Parkin, can be found on the editorial page of last month's issue of the AERONAUTICAL ENGINEERING REVIEW. However, photographs of the ten newly elected I.A.S. Fellows and the four award winners, as well as pertinent details concerning the awards themselves, are located elsewhere in this issue.

▸ **Dinner Speaker**—The Guest of Honor and Principal Speaker of the evening was The Honorable Charles E. Wilson, Director, Office of Defense Mobilization, who spoke on "A Revolution in Technique." Mr. Wilson's address will be found on page 30 of this issue.

▸ **Technical Sessions**—Every one of the 14 technical sessions was marked by good attendance, excellent papers, and discussions par excellence. In recognition of the paramount position now assumed by electronics in aeronautical design and operation, three of the sessions—an entire day—were given over to the problems and trends in this particular field of the aeronautical sciences. The Institute of Radio Engineers, Radio Technical Commission for Aeronautics, and Institute of Navigation cooperated with the I.A.S. in planning these sessions.

The sessions on Motorless Flight, Meteorology, Rotating Wing Aircraft, and Rocket Propulsion were given in cooperation with The Soaring Society of America, American Meteorological Society, American Helicopter Society, and American Rocket Society.

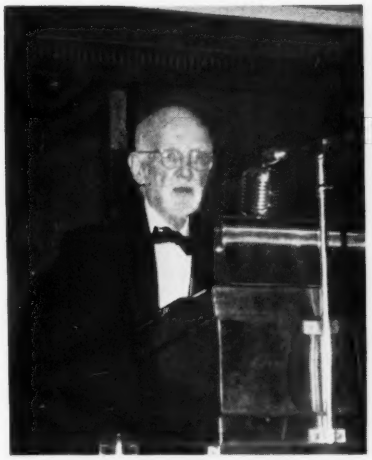
For the second year, the May issue of the REVIEW will be given over to the role of electronics in aviation. In it will be published in full the four papers delivered in the morning session on the "Impact of Electronic Trends on Aircraft Design," the four papers from the afternoon session on "Problems Encountered in Today's High Speed Flights," and the evening's "Symposium—All-Weather Operation Problems."

▸ **Annual Business Meeting**—In accordance with the I.A.S. Constitution and By-Laws, the Institute's Annual Business Meeting was held on the last Wednesday in January. Several hundred members attended in person; hundreds of others were represented by proxies.

The yearly reports of the President, Director, Secretary, and Treasurer were read and approved. These reports, together with pictures of the 1952 I.A.S. Council, appear on succeeding pages.

▸ **Publication of Papers**—Many of the papers presented at the Annual Meeting were received in time to be preprinted through the Sherman M. Fairchild Fund. Copies of those available in this form are listed on the Preprint Page of this issue (page 87).

Publication of most of the papers presented at the meeting is scheduled for the earliest possible issues of either the JOURNAL OF THE AERONAUTICAL SCIENCES or the AERONAUTICAL ENGINEERING REVIEW.



**Dean of America's Aeronautical Engineers:** *The most stirring event at the recent Honors Night Dinner was the talk given by 92-year-old Dr. William Frederick Durand (above). Dr. Durand, who is noted for his six-volume classic, "Aerodynamic Theory," gave his address during the presentation of monies to the Institute by Dr. Clark B. Millikan, acting in behalf of the Durand Reprinting Committee. This sum of money will be used for the establishment of the W. F. Durand Aeronautical Museum at the Institute's building in Los Angeles.*

# I.A.S. Awards and

**Captain John R. Poppen** (MC), U.S.N. (Ret.), formerly Director, Aviation Medical Acceleration Laboratory.

## The John Jeffries Award

This award honors the memory of Dr. John Jeffries, an American physician who, with Blanchard, the French balloonist, made the first aerial voyage across the English Channel in 1785 and on a previous voyage made the earliest recorded scientific observation from the air. This award, which has an honorarium of $200, was established by the Institute in 1940 to give recognition to the importance to aviation of scientific endeavor in the field of medicine.

*Presented to* CAPTAIN JOHN R. POPPEN (MC), U.S.N.

*"For outstanding contributions to the advancement of aeronautics through medical research."*

Captain Poppen's most significant contribution to the advancement of aeronautics through medical research is considered by many to be his scientific investigations and resultant findings relating to the field of acceleration and its effects on pilots. His findings, in this respect, led directly to the development of the currently used G-suits.

Continuously engaged in the field of Aviation Medicine for the past 30 years, Captain Poppen has also contributed other things of vital importance to aeronautics. These have included: (1) initiating research that led to the present Navy methods of selecting flight personnel; (2) developing many items of flight equipment—viz., oxygen equipment, immersion suits, exposure equipment, and the Navy emergency ejection seat; (3) research that has provided industry with the best human engineering requirements for ejection seats, capsules, and pods; and (4) determining the values of sound and vibration as they develop in aircraft and the methods for their abatement.

Immediately before his retirement on January 1, 1952, Captain Poppen was Director of the Aviation Medical Acceleration Laboratory, U. S. Naval Air Development Center, Johnsville, Pa.

**Ivan R. Tannehill,** Chief, Division of Synoptic Reports and Forecasts, U.S. Weather Bureau.

## The Robert M. Losey Award

Established in 1940, this award honors the memory of Captain Robert Moffatt Losey, a member of the Institute and a meteorologic officer of the Air Corps, who was killed at Dombas, Norway, April 21, 1940, while serving as an official observer for the U.S. Army. He was the first officer in the service of the United States to die in World War II. This award carries an honorarium of $200.

*Presented to* IVAN R. TANNEHILL

*"In recognition of outstanding contributions to the science of meteorology as applied to aeronautics."*

Mr. Tannehill, a research worker in the problems of atmosphere, has figured prominently in the development and maintenance of the international network of synoptic weather reports upon which present-day aeronautics is strongly dependent. Through the medium of the various international committees on which he has served, his progressive ideas have been applied throughout the world. He was a member for many years of the International Commission on Synoptic Weather Reports. From 1947 to 1951, he was President of the Commission on Synoptic Meteorology of the International Meteorological Organization.

Mr. Tannehill has devoted himself for many years to the improvement and expansion of the upper air network that is the very foundation of American aeronautical meteorology. In addition to his outstanding work in the field of synoptic reports and networks, he is the author of many authoritative books and papers on such subjects as hurricane, drought, world weather, and synoptic climatology.

Mr. Tannehill has served on various interdepartmental boards and committees that have been responsible for shaping the course of practical services in aeronautical meteorology over the past two decades.

# Honors for 1951

**Edward H. Heinemann,** Chief Engineer, El Segundo Division, Douglas Aircraft Company, Inc.

## The Sylvanus Albert Reed Award

*For a notable contribution to the aeronautical sciences resulting from experimental or theoretical investigations which have had a beneficial influence on the development of practical aeronautics.*

The late Dr. S. A. Reed, designer of metal aircraft propellers and a Founder Member of the Institute, made an endowment to the Institute in 1933 to provide an annual award with a certificate and honorarium of $250. The recipient of this award is chosen by the ballot of the American Honorary Fellows and Fellows of the Institute.

*Presented to* EDWARD H. HEINEMANN

*"For design and development of experimental aircraft for investigating transonic and supersonic flight phenomena."*

Mr. Heinemann's contributions to the advancement of aviation have been numerous and diverse over the last 25 years. His current aircraft projects cover all four of the major power-plant fields; i.e., reciprocating, turbojet, turboprop, and rocket. These have included: the Skyraider (AD), Skynight (F3D), Skyshark (A2D), and Skyrocket (D558) series.

The D558-2 Skyrocket is the most widely heralded of Mr. Heinemann's designs. In August, 1951, the Skyrocket reportedly set new world's altitude and speed records for airplanes of any type. The flight tests conducted to date with the Skyrocket have provided invaluable flight engineering knowledge on drag, buffet intensity, lift coefficients, and stability phenomena in the transonic range. The Skyrocket will, according to present plans, be employed in the near future in the investigation of the problems of dynamic stability and control and high supersonic speeds.

**Robert C. Seamans, Jr.,** Associate Professor, Aeronautical Engineering, Massachusetts Institute of Technology.

## The Lawrence Sperry Award

*For a notable contribution made by a young man to the advancement of aeronautics.*

This award was endowed in 1936 by the sister and brothers of the late Lawrence Sperry, pioneer aviator and inventor, who died in 1923 at the age of 31. It provides an annual certificate of citation and an honorarium of $250 to the recipient selected by the Board of Award.

*Presented to* ROBERT C. SEAMANS, JR.

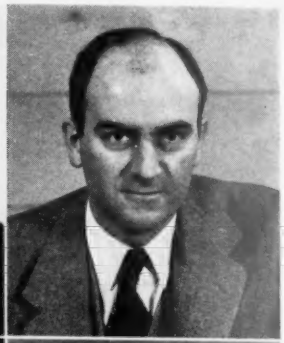
*"For a system of determining dynamical characteristics of an airplane and matching them to automatic controls by measuring the pulse excited response in flight."*

Professor Seamans, who received his B.S. degree from Harvard in 1939, his M.S. from M.I.T. in 1941, and his Sc.D. from M.I.T. in 1951, has been on the M.I.T. staff since his graduation. The bulk of his work since that time has been classified; however, it may be said that it has covered the fields of vibration measurements, special flight-test instrumentation, and fire-control instrumentation. He has carried his developments from the theoretical stage through the drafting room and shops to the testing of the final working model. In this same manner, he has developed special flight-test instruments for the U.S. Air Force and U.S. Navy.

A further extension of Professor Seamans' work on "control systems engineering" to automatic piloting of airplanes led to the first successful automatic tracting of an invisible target plane by air-borne radar. This was accomplished by determining the dynamical characteristics of the airplane by its pulse-excited response in flight. Unfortunately, further details of this application are classified.

# I.A.S. Fellows for 1952

**A. T. Colwell,** Vice-President, Thompson Products, Inc.



**Leo J. Devlin, Jr.,** Chief Designer and Assistant Chief Engineer, El Segundo Division, Douglas Aircraft Company, Inc.

**Robert R. Dexter,** Secretary, Institute of the Aeronautical Sciences, Inc.

**Harold D. Hoekstra,** Assistant Director for Prototype Aircraft Development, Office of Aviation Safety, Civil Aeronautics Administration

**Nicholas J. Hoff,** Professor and Head, Department of Aeronautical Engineering and Applied Mechanics, Polytechnic Institute of Brooklyn

**Hans W. Liepmann,** Professor of Aerodynamics, California Institute of Technology

**Major Gen. Donald L. Putt,** Vice-Commander, Air Research and Development Command, Md.

**Daniel Sayre,** Director, James Forrestal Research Center, Princeton University

**Ernest G. Stout,** Assistant to Chief Engineer, Consolidated Vultee Aircraft Corporation

**Walter G. Vincenti,** Aero Research Scientist, Ames Aeronautical Laboratory, N.A.C.A.

# Annual Business Meeting of the Institute

## *Reports of President, Treasurer, and Director*

THE TWENTIETH ANNUAL MEETING of the members of the Institute was held at the Hotel Astor, New York, on January 30, 1952. The President, Lawrence B. Richardson, presided.

Mr. P. R. Bassett, Teller, reported that he had received and counted 936 valid proxies for voting at the Annual Meeting—a quorum of the voting membership. Dr. T. P. Wright, Chairman of the Nominating Committee, placed in nomination the following members for election to vacancies on the Council: Wellwood E. Beall, L. B. Richardson, P. R. Bassett, S. J. De France, E. H. Heinemann, John Leslie, and Charles H. Colvin, for a term of 1 year each; J. L. Atwood, Ralph Damon, E. M. Lester, Clark B. Millikan, and E. R. Sharp, for a term of 3 years each; and the following area councilors for a term of 1 year each: Eastern Area—William B. Bergen and H. J. E. Reid; Central Area—Herbert W. Hinckley and George M. Melby; Western Area—Dwight H. Bennett and Robert E. Hage. On motion duly made, seconded, and carried, they were unanimously elected. The following were nominated and elected in like manner to serve on the Nominating Committee for 1952: Hugh L. Dryden, Chairman, E. E. Aldrin, C. C. Furnas, Charles Froesch, R. Paul Harrington, J. C. Hunsaker, Clark B. Millikan, and John K. Northrop.

The Annual Reports of the President, Treasurer, and Director were read and approved. (See the following pages for the complete reports.)

Dr. J. C. Hunsaker suggested that the Institute give some consideration toward the establishment of a student aid program in the form of scholarships and fellowships.

The Secretary presented a list of honors conferred by the Institute in 1951 as follows:

The Thurman H. Bane Award to J. B. Johnson, Head, Metallurgy Group, Office of Air Research, Air Development Force, A.R.D.C.; The Octave Chanute Award to Lt. Col. Marion E. Carl, U.S.M.C., Head of the Carrier Aircraft Section, Flight Test Division, N.A.T.C., Patuxent, Md.; The John Jeffries Award to Capt. John R. Poppen, (MC) U.S.N. (Ret.); The Robert M. Losey Award to Ivan R. Tannehill, Chief of Division of Synoptic Reports and Forecasts, U.S. Weather Bureau; The Sylvanus Albert Reed Award to E. H. Heinemann, Chief Engineer, El Segundo Division, Douglas Aircraft Company, Inc.; The Lawrence Sperry Award to Robert C. Seamans, Jr., Associate Professor, Aeronautical Engineering, Massachusetts Institute of Technology; and the Wright Brothers Lecturer, Dr. P. B. Walker, Head of the Structures Department, Royal Aircraft Establishment, who spoke on "The Experimental Approach to Aircraft Structural Research."

Honorary Fellowships in the Institute to: American—Leroy R. Grumman, Chairman, Board of Directors, Grumman Aircraft Engineering Corporation; Foreign—J. H. Parkin, Director, National Aeronautical Establishment, Canada.

Fellowships in the Institute to: A. T. Colwell, Vice-President, Thompson Products, Inc.; Leo J. Devlin, Jr., Chief Designer and Assistant Chief Engineer, El Segundo Division, Douglas Aircraft Company; Robert R. Dexter, Secretary, Institute of the Aeronautical Sciences, Inc.; Harold D. Hoekstra, Assistant Director for Prototype Aircraft Development, Office of Aviation Safety, C.A.A.; Nicholas J. Hoff, Professor and Head, Department of Aeronautical Engineering and Applied Mechanics, Polytechnic Institute of Brooklyn; Hans W. Liepmann, Professor of Aerodynamics, California Institute of Technology; Maj. Gen. Donald L. Putt, Vice-Commander, Air Research & Development Command; Daniel Sayre, Director, James Forrestal Research Center, Princeton University; Ernest G. Stout, Assistant to Chief Engineer, Consolidated Vultee Aircraft Corporation; Walter G. Vincenti, Aero Research Scientist, Ames Aeronautical Laboratory, N.A.C.A.

The Secretary announced that the Council had elected the following officers of the Institute for 1952: President, Wellwood E. Beall; Vice-Presidents, P. R. Bassett, S. J. De France, E. H. Heinemann, and John Leslie; Director, S. Paul Johnston; Treasurer, Charles H. Colvin; Secretary, Robert R. Dexter; and Controller, Joseph J. Maitan.

ROBERT R. DEXTER, *Secretary*

# President's Report

THE YEAR 1951 was an active period for the Institute. A detailed account of its general activities and its fiscal position will be found in the reports of the other officers which follow. As retiring President, I want to make only a few general observations on an overall basis.

First of all, in a period of national crises (and we are all becoming fairly well accustomed to them by now), there is reason to examine every activity in which we are engaged to see if its continuation is really worth the effort. If the answer is "yes," it is essential that we make certain that we work toward our objectives in the most efficient way.

As far as the scientific and engineering societies in general are concerned—and for the Institute in particular—I think we can all agree that their value to the defense effort is beyond question and tends to augment rather than to decrease as this particular kind of crisis becomes more and more acute.

This is the Institute's Twentieth Anniversary year. In its past 20 years it has created a firm place for itself in the American Aeronautical scene both in peace and in war. From its beginning in 1932, it has consistently had but one objective, to advance the art and science of aeronautics. Tremendous things have happened in its relatively brief lifetime. Few people in 1932 could have foreseen the things that are now commonplace—600–700 m.p.h. fighter speeds in being, supersonic speeds in the offing, or transatlantic air travel running ahead of travel by sea. We have come a long, long way, and we are going much further; but in the future, as in the past, we can be certain that the men who will make the impossible practical in aviation will be members of the Institute.

During the years, the I.A.S. has become international in scope. We have many members in various countries of the free world. We have three sections in Canada, and, as most of you know, the Third International Conference with the Royal Aeronautical Society was held in England in September, 1951. These meetings, begun experimentally in 1947, have now become a fixed part of our program. Plans for the Fourth Conference, to be held somewhere in the United States in 1953, are already being laid by the Council.

As you will note from the Treasurer's Report, the Institute's financial position has never been more satisfactory. Our income exceeded our expenditures during the year, permitting us to set up some operating reserves and to add some to our surplus account. The outlook for next year is even better.

One long-standing problem was resolved during the year by the sale of the Guggenheim property at Sands Point, Long Island, to the United States Navy. The Special Devices Division of the Office of Naval Research has occupied the property for the past 6 years under

lease, and negotiations have been under way for over 2 years to permit its purchase. These were satisfactorily completed and title was passed on October 17, 1951. The proper use of the Fund resulting from the sale is now being considered by the Council.

In closing my term of office as President, I should like to pay a tribute to the members of the Council of the Institute. I am sure that no Board of Directors has ever taken more active interest in their operations than do the members of the Institute's Council. This organization is indeed fortunate in having the wholehearted interest and support of men of the caliber of our Council. They provide the intelligent and continuous type of policy direction that such an organization as this needs to keep it constantly alive to meet the needs of its membership and of the industry it serves.

In closing I wish to thank the Council, Officers, and Members for the support and cooperation given to me as your president.

REAR ADM. L. B. RICHARDSON, U.S.N. (RET.), *President*

# Treasurer's Report

WHEN THE LATE Charles L. Lawrance presented his first complete statement of operations for the period October 15, 1932, to September 30, 1933, at the Institute's Second Annual Meeting, he probably never anticipated that his balance sheet with assets of $1,176.92 would total $448,791.42 in1951, excluding restricted funds donated during the past years. In 1934, I succeeded Mr. Lawrance as Treasurer and at the end of my year stated that it was a pleasure to present a satisfactory report. After 17 years, during which period many members of prominence served as Treasurers, that remark can be reiterated.

During my tenure in office the financial position of the Institute was constantly checked, expenses scrutinized carefully, and all procedures continually improved. Monthly statements were prepared for review by your Executive Committee and Council.

The adoption of a policy whereby the various Funds were combined for investment purposes has worked out satisfactorily. These Funds are invested at present on a basis of 55 per cent in Government bonds, 18 per cent in other fixed income securities such as industrial or railroad bonds and preferred stocks, and the balance of 26 per cent is invested in high grade common stocks. The Finance Committee, whose responsibility it is to safeguard the investments to the best of its ability, meets every 3 months and works closely with the Investment Service Division of the Chase National Bank. The Committee's efforts are reflected in the auditor's report by the statement that the market values of the investments are $45,196.45 in excess of the present book value, indicating prudent management of funds by the Committee.

The day-to-day operations of the national office show an increase in income of 23 per cent and an increase in expenses of 18 per cent over the previous year's operations. The net operating income for fiscal 1951 was $19,836.01 compared with $2,336.01 for fiscal 1950. Reserves in the amount of $17,500 were provided to meet future activities, and the balance of $2,336.01 was transferred to our net unexpended income account.

The greatest increase in income was from advertising in the REVIEW. This increase percentage-wise was greater than that of any other aeronautical publication in the field, and, as a result of this volume of advertising, it has been possible to publish additional papers during the year.

The 1950 CATALOG was produced at a net cost of slightly over $1,800 as a result of a revised format that year. The 1951 edition earned $1,867.52, overcoming the previous year's deficit. The JOURNAL, which is available to members at $4.00 a year, even though it costs in excess of that special subscription price merely to print and post, again showed in the black.

In Los Angeles, our building was operated at a loss of $2,309.68, principally because of an increase of about 50 per cent in property taxes. The Los Angeles Building Advisory Management Committee is fully familiar with all of the operating phases of the building, and it is expected that the situation will be remedied before long. The San Diego Building is still under lease to the Consolidated Vultee Aircraft Corporation.

The Pacific Aeronautical Library showed an excess of income over expenses of $1,286.85, which, when added to prior earnings, increases its net unexpended income to $10,157.40. This unexpended income, as with that of the national office, is a reserve to be used in maintaining services when required.

Negotiations with the Government for the purchase of the Institute's Sands Point property were concluded on October 17, 1951, which is subsequent to this fiscal year report and will be reported by your next Treasurer.

A conservative budget for 1951–1952 has been prepared and approved by your Council, and the Institute expects to operate in the black for 1951–1952.

A copy of the statement of operations and the balance sheet is published on page 25 in digest form for your perusal. The books were audited by Harris, Kerr, Forster & Company, Certified Public Accountants, who state that the report fully presents the financial position of the Institute.

In closing, should any member desire further information on the Institute's financial transactions, contact Joseph J. Maitan, our Controller, who can furnish all details.

E. E. ALDRIN, *Treasurer*

# Director's Report

AS POINTED OUT by our Retiring President, the Institute has rounded up the year 1951 in excellent shape. Its activities have been held at a high level; its financial position is sound; and the outlook for its "next 20 years" is most favorable.

## Meetings

Institute meetings are one yardstick of its activity. All national meetings were well attended, and the international meeting turned out over 100 U.S. delegates.

The year's schedule included: Nineteenth Annual Meeting, New York, January, 1951; Sixth Annual Propulsion Meeting, Cleveland, March; Summer Annual Meeting, Los Angeles, June; Third International Conference, England, September; Fourteenth Wright Brothers Lecture, Washington, December.

In the same period of time, our 24 Sections held 168 meetings, and our 71 Student Branches reported 323 sessions.

## Membership

Total membership shows a continuing steady rise. No national campaigns were conducted, but, in the course of the year, over 350 new applications were processed. The normal annual attrition was more than made up by new admissions. The number of graded members now organized in sections is noteworthy.

# INSTITUTE OF THE AERONAUTICAL SCIENCES, INC.

## Statement for the fiscal year October 1, 1950, to September 30, 1951

### Consolidated Balance Sheet and Operating Statement

**ASSETS**

| | | |
|---|---|---|
| *General Fund Assets:* | | |
| Cash on Deposit | $149,097.46 | |
| Accounts Receivable—Net | 32,300.60 | |
| Advances on Intrafund Accounts | 28,724.54 | |
| Deposits and Prepayments | 13,987.84 | |
| Furniture and Fixtures | 5,000.00 | |
| Investments | 219,677.98 | |
| Daniel Guggenheim Park | 1.00 | |
| Books, Prints, Models, Medals, etc. | 1.00 | |
| Aeronautical Index | 1.00 | |
| **Total General Fund Assets** | | $448,791.42 |
| *Restricted Fund Assets:* | | |
| The Thurman H. Bane Award Fund | $ 600.00 | |
| The Sherman M. Fairchild Fund | 15,022.19 | |
| The Paul Kollsman Fund | 69,000.00 | |
| The Vernon Lynch Award Fund | 39,560.58 | |
| The Minta Martin Aeronautical Fund | 547,557.13 | |
| The Sylvanus Albert Reed Award Fund | 13,537.35 | |
| The Lawrence Sperry Award Fund | 13,302.00 | |
| Los Angeles Building Operating Fund | 15,467.19 | |
| Pacific Aeronautical Library Fund | 12,347.05 | |
| New York Building, Maintenance, and Reserve Fund | 324,940.50 | |
| Los Angeles Building and Reserve Fund | 398,741.79 | |
| San Diego Building and Reserve Fund | 176,706.11 | |
| **Total Restricted Fund Assets** | | $1,626,781.89 |

**LIABILITIES, RESERVES, AND UNEXPENDED INCOME**

| | | |
|---|---|---|
| *General Fund:* | | |
| Accounts Payable and Deposits | $ 61,287.90 | |
| Deferred Credits to Income (Dues and Subscriptions) | 86,011.11 | |
| Deferred Income—San Diego Building | 11,777.31 | |
| Reserves—Miscellaneous | 30,259.00 | |
| *Unexpended Income:* | | |
| Balance September 30, 1951 | 259,456.10 | |
| **Total Liabilities, Reserves, and Unexpended Income** | | $448,791.42 |
| *Restricted Funds:* | | |
| Principal of Gifts and Unexpended Income (See Assets) | | |
| **Total Restricted Fund Liabilities** | | $1,626,781.89 |

### Statement of Income and Expenses

GENERAL

**INCOME**

| | | |
|---|---|---|
| Dues (less subscriptions) | $166,106.60 | |
| Entrance Fees | 3,000.00 | |
| Investment Income | 10,809.12 | |
| Miscellaneous | 1,250.03 | |
| *Excess of Income over Expenses:* | | |
| Journal of the Aeronautical Sciences | 963.76 | |
| Aeronautical Engineering Catalog | 1,867.52 | |
| Aeronautical Engineering Review | 34,502.47 | |
| **Total Income** | | $218,499.50 |

**EXPENSES**

| | | |
|---|---|---|
| Administrative and Clerical Salaries | $106,333.34 | |
| General Office Expenses—Net | 72,192.47 | |
| Library Costs | 18,570.57 | |
| Archives Costs | 1,567.11 | |
| Add: Provisions for Contingencies | 17,500.00 | |
| **Total Expenses** | | $216,163.49 |
| **Net Operating Income for the Year Ending September 30, 1951** | | $2,336.01 |

JOURNAL

**INCOME**

| | | |
|---|---|---|
| Subscriptions | $34,332.73 | |
| Reprints | 780.40 | |
| **Total Income** | | $35,113.13 |

**EXPENSES**

| | | |
|---|---|---|
| Editorial and Clerical Salaries | $ 7,067.00 | |
| Publication and Other Expenses | 27,082.37 | |
| **Total Expenses** | | $34,149.37 |
| **Excess of Income over Expenses (See General Income)** | | $963.76 |

REVIEW

**INCOME**

| | | |
|---|---|---|
| Advertising Revenue | $148,615.45 | |
| Subscriptions | 19,015.22 | |
| **Total Income** | | $167,630.67 |

**EXPENSES**

| | | |
|---|---|---|
| Editorial, Advertising, and Clerical Salaries | $40,073.86 | |
| Publication and Other Expenses | 93,054.34 | |
| **Total Expenses** | | $133,128.20 |
| **Excess of Income over Expenses (See General Income)** | | $34,502.47 |

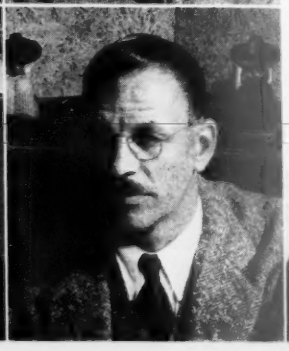
CATALOG

**INCOME**

| | | |
|---|---|---|
| Advertising Revenue | $22,100.00 | |
| Sales and Reprints | 938.35 | |
| **Total Income** | | $23,038.35 |

**EXPENSES**

| | | |
|---|---|---|
| Editorial and Advertising Salaries | $ 5,442.00 | |
| Publication and Other Expenses | 15,728.83 | |
| **Total Expenses** | | $21,170.83 |
| **Excess of Income over Expenses (See General Expenses)** | | $1,867.52 |



# Newly Elected Members of the Institute Council

### Eastern Area

**William B. Bergen,** Vice-President and Chief Engineer, The Glenn L. Martin Company

**H. J. E. Reid,** Director, Langley Aeronautical Laboratory, N.A.C.A.

### Central Area

**Herbert W. Hinckley,** Assistant Chief Engineer, Fort Worth Division, Consolidated Vultee Aircraft Corporation

**George M. Melby,** Instructor, Aeronautical Engineering, College of Engineering, Wayne University

### Western Area

**Dwight H. Bennett,** Assistant Project Engineer, Consolidated Vultee Aircraft Corporation

**Robert E. Hage,** Senior Group Engineer, Preliminary Design Department, Boeing Airplane Company

### Council Members

**J. L. Atwood,** President, North American Aviation, Inc.

**Ralph S. Damon,** President, Trans World Airlines, Inc.

**E. M. Lester,** Assistant General Manager, Fairchild Engine Division, Fairchild Engine and Airplane Corporation

**Clark B. Millikan,** Director, Guggenheim Aeronautical Laboratory, California Institute of Technology

**Edward R. Sharp,** Director, Lewis Flight Propulsion Laboratory, N.A.C.A.

MEMBERSHIP BREAKDOWN
Comparisons by Calendar Year

| | 12/31/49 | 12/31/50 | 12/31/51 |
|---|---|---|---|
| Temporary Honorary Members | 17 | 18 | 14 |
| Honorary Fellows | 21 | 22 | 24 |
| Fellows | 184 | 184 | 183 |
| Associate Fellows | 624 | 635 | 665 |
| MEMBERS | 3,108 | 3,114 | 3,218 |
| Associate Members | 405 | 367 | 368 |
| Historical Associate Members | 56 | 68 | 67 |
| Technical Members | 3,449 | 3,899 | 4,102 |
| Total Graded Members | 7,864 | 8,307 | 8,641 |
| Student Members | 3,958 | 3,395 | 3,006 |

Because of the reduction of the number of students in colleges (due to the termination of the G.I. Bill and to the uncertainties of the Korean situation), there has been a tapering off in student members for the past 3 years.

## Publications

As will be noted in the Treasurer's Report, all I.A.S. publications are now in excellent financial shape. The only one operating at a loss is the ROSTER, but the intension has been to carry only a limited amount of advertising at very low rates (offered to our Corporate Members and REVIEW advertisers) to help offset the cost of this membership service.

The editorial content of the JOURNAL was expanded in 1950, and the same level has been maintained through 1951.

The REVIEW has shown a rising gain of income over expense, in spite of the continual increase in costs of printing. Its editorial policies appear to be satisfactory to our membership, and its advertising pages are in increasing demand. The outlook for the current year is most encouraging.

The CATALOG is also in a satisfactory position. It is now generally accepted as the standard handbook and directory of air-borne accessories and equipment. It should show a greater gain in 1952 than it did in 1951.

The Third International Conference papers and discussions were published in loose-leaf form by the Royal Aeronautical Society and were distributed to our delegates. We did not, therefore, have the publishing load in that connection that we carried in 1949–1950.

During the year, the Sherman Fairchild Fund added 50 new titles to its list and distributed approximately 10,000 copies of reports.

The publication of AERONAUTICA was continued through 1951.

## Library Services

The demands on both librarians (New York and Los Angeles) are increasing because of the general increase in industry activity. The Los Angeles library in particular has been extremely active under the able direction of Mrs. Nell Steinmetz. In New York, a change in our library organization resulted from the resignation of Maurice H. Smith, who is now Research Associate (Library) for the James Forrestal Research Center of Princeton University. Mr. John Glennon, long associated with Mr. Smith in our library work, is now in charge as Acting Librarian.

## Buildings

The operation of all I.A.S. buildings continued to be satisfactory in 1951. In the New York headquarters a revision of the lighting system to improve conditions in all offices was completed. Also, because of deterioration of much of the original painting job, most of the working spaces were redecorated during the year. Both those jobs were carried out within the limits of the building maintenance reserve fund set up in the fiscal year 1950–1951.

Operation of the Los Angeles facility is satisfactory. A program of continuous improvement under the direction of our Western Manager, E. W. Robischon, is being carried on as fast as budget permits. After 3 years of continuous and hard use certain defects have come to light, but they are being corrected.

During the entire year the San Diego facility has been occupied by Convair, Inc., for war emergency use, under lease from the Institute.

As pointed out in the President's Report, the former Guggenheim property at Sands Point was sold to the U.S. Navy in October, 1951.

## Staff

No major changes in staff organization occurred during 1951. Our working group is closely integrated and is doing an excellent job in carrying out the policies and program of your Institute.

S. PAUL JOHNSTON, *Director*

## Navy Symposium on Aeroballistics

A Navy Symposium on Aeroballistics, under the sponsorship of the Bureau of Ordnance, will be held at the Huntington Hotel in Pasadena, Calif., May 13 and 14, 1952. The meeting will be followed by a visit to the Naval Ordnance Test Station at Inyokern on May 15. The meeting will be closed, and a confidential clearance is required for attendance. The subjects to be discussed include aeroelasticity, aircraft missile interaction, heat transfer, hypersonics, scaling effects, relaxation phenomena, and studies conducted in the pressurized ballistic range and the shock tube.

Those wishing to attend should address their requests to the Chairman, Bureau of Ordnance Aeroballistics Committee (Code Rexd-2), Department of the Navy, Washington 25, D.C.

# General News

## 1951 I.A.S. President Joins Electric Boat

Rear Admiral Lawrence B. Richardson, U.S.N. (Ret.), F.I.A.S., who at the Twentieth Annual Meeting added his name to the distinguished list of I.A.S. Past Presidents, has accepted a position with Electric Boat Company as Senior Vice-President and Director. At the same time, he also became a Director of Canadair, Ltd., a subsidiary of Electric Boat.

Admiral Richardson, who until recently was Director of Research and Development for Fairchild Engine and Airplane Corporation has had an exceptionally broad experience in the design, development, manufacture, and inspection of aircraft, as well as a long career in naval aviation. He retired in 1946 from the Navy after more than two decades in the service. Admiral Richardson was awarded the Legion of Merit by the Navy in 1946.

## I.A.S. Members Inducted As S.A.E. Officers

Dr. Daniel P. Barnard IV, A.F.I.A.S., Research Coordinator, Standard Oil Company (Indiana), was installed as President for 1952 of the Society of Automotive Engineers at the society's annual business meeting.

In addition to Dr. Barnard, three other I.A.S. members were elected to office. They are: D. R. Shoults, A.F.I.A.S., Director, Aircraft Nuclear Propulsion Project, General Electric Company; Frank C. Mock, A.F.I.A.S., Manager—Fuel Feed Engineering, Bendix Products Division, Bendix Aviation Corporation; and Wellwood E. Beall, I.A.S. Fellow and 1952 President, Senior Vice-President, Boeing Airplane Company. Messrs. Shoults and Mock are serving as two of S.A.E.'s twelve Vice-Presidents and head, respectively, the Aircraft and the Aircraft Powerplant Professional Activities. Mr. Beall is serving as a member of the S.A.E. Council.

Dr. D. P. Barnard IV.

Dr. Barnard, who won the S.A.E. Horning Memorial Award for 1949, has been a member of the N.A.C.A. subcommittee on fuels since 1940. During World War II, he served as Aviation Advisor to the Petroleum Administration for War.

## I.A.S. Members on Columbia University Committee

Three members of the Institute of the Aeronautical Sciences are among those persons who comprise the Committee of Sponsors for the Columbia University Engineering Center Development Fund. They are: Capt. Ralph S. Barnaby, U.S.N. (Ret.), F.I.A.S., Chief, Aeronautics Section, Electronics and Instrument Division, Franklin Institute Laboratories for Research and Development; Charles Marcus, A.M.I.A.S., Vice-President, Bendix Aviation Corporation; and Thomas A. Morgan, A.M.I.A.S., President and Chairman of the Board, The Sperry Corporation.

Grover Loening, I.A.S. Fellow and Benefactor, Consultant on Aircraft, is a member of the Alumni Special Gifts Committee for Civil Engineers in the Development Fund.

The Engineering Center, for which $22,150,000 is being raised, is scheduled for completion in time for Columbia University's bicentennial anniversary in 1954. One building on the site at Riverside Drive and 125th Street in New York City is already partly occupied.

## R.P.I.'s Wind Tunnel

The wind tunnel recently completed at Rensselaer Polytechnic Institute was built by the Department of Aeronautical Engineering and represents one of the few known instances in which such a complex and expensive structure has been built entirely within a technological department of a private institution.

The plans used in the construction of this tunnel were prepared about 4 years ago by Robert Gordon Campbell, M.I.A.S., and Ray E. Boltz, of the Department of Aeronautical Engineering. Mr. Boltz has since left Rensselaer; however, the construction of the general frame and sheet-metal work has been supervised during the past 2 years by Professor Campbell. Henry Burlage, T.M.I.A.S., Assistant Professor of Aeronautical Engineering, who designed the nozzle throat and its case, supervised its construction during the last year.

This apparatus, which develops air speeds up to Mach Number 3, is powered by a Rolls-Royce Merlin 12-cylinder airplane engine on loan from the U.S. Army. The tunnel is currently available for both instruction and research uses.

## Naval Symposium on Jet Airfields

The U.S. Naval Civil Engineering Research and Evaluation Laboratory of the Bureau of Yards and Docks is sponsoring a symposium on "Airfield Pavements for Jet Aircraft." It will be held in Port Hueneme, Calif., on April 17–18, 1952.

The object of this symposium is to encourage and facilitate the interchange of information and ideas among various groups engaged in research aimed toward the design or modernizing of airfield pavements to withstand the effects of jet-powered aircraft. For further information, contact J. A. Bishop, Director, Soils and Pavements Division, Structures Research Department, Port Hueneme.

# Necrology

## Commander Frank Welch, Jr.

Commander Frank Welch, Jr., U.S.N., T.M.I.A.S., Commanding Officer, VF-111, Fleet Post Office, San Francisco, was killed on October 29, 1951.

Born in New Orleans on November 17, 1918, Commander Welch attended high school in San Diego and in Arlington, Mass. After a year at the Massachusetts Institute of Technology, he entered the U.S. Naval Academy in 1937 and was graduated from there in February, 1941.

After completing his flight training in 1944, Commander Welch was assigned to duty in various Naval Fighter Squadrons as Pilot, Operations, and Executive Officer. He was sent to the U.S. Naval Postgraduate School from 1947 to 1949 and to the California Institute of Technology from 1949 to 1950. He received his professional degree in aeronautical engineering from CalTech in June, 1950.

Commander Welch, who also held a C.A.A. Commercial Pilot's Certificate for single-engined land aircraft, is survived by his wife, Joan V. Welch.

# News of Members

▸ **Charles O. Cary** (A.F.), Executive Secretary, Air Coordinating Committee, has been appointed Deputy Administrator, Defense Air Transport Administration, U.S. Department of Commerce. Mr. Cary will assume these new duties in addition to his present duties.

▸ **Dr. Karl T. Compton** (F.), Chairman of the Corporation, Massachusetts Institute of Technology, was elected a Director of General Motors Corporation on January 7. Dr. Compton is also Chairman of the Research and Development Board, National Military Establishment.

▸ **Major General Oliver P. Echols** (F.), General Manager and Chairman of the Board, Northrop Aircraft, Inc., has been elected a California Director of the National Association of Manufacturers.

▸ **Walter Fitch** (A.M.), Kansas Governor of The Soaring Society of America, has been appointed Leader Member, Academy of Model Aeronautics.

▸ **Francois N. Frenkiel** (A.F.), Physicist, Applied Physics Laboratory, The Johns Hopkins University, was elected to serve as a member of the Executive Committee, Fluid Dynamics Division, American Physical Society.

▸ **Harry F. Guggenheim** (H.M., M.) has announced the formation of a new Guggenheim Brothers partnership to carry on certain of that family's interests in mining and metallurgical enterprises and to engage in research and new business. The other members of the new partnership are the Messrs. J. P. Doetsch, A. E. Thiele, A. C. Van de Maele, R. P. Miller, and H. R. Graham.

▸ **Edward A. Ledeen** (M.), Administrative Engineer, Haines Designed Products Corporation, reports that his company is sending gratis to any interested persons a four-page technical booklet, *Instrument Shock Testing Theory and Measurement*, which describes in detail the use of the Haines Shock Testing Mechanism that conforms to the Army-Navy Specification #JAN-S-44.

▸ **Dr. Edward R. Sharp** (F.), Director, Lewis Flight Propulsion Laboratory, N.A.C.A., served as General Chairman for the fifth annual National Model Plane Exhibit Contest, which was held in Cleveland on February 23.

▸ **Morril B. Spaulding, Jr.** (M.), has opened his own law firm at Room 800, 726 Jackson Place, N.W., Washington, D.C. This office will provide both technical and legal representation for aviation firms. Mr. Spaulding was formerly Assistant Director, Engineering Division, Air Transport Association.

▸ **Juan T. Trippe** (A.M.), President, Pan American World Airways, Inc., is the Chairman of the Airlines Division in the current polio appeal of the National Foundation for Infantile Paralysis in Greater New York.

▸ **Gill Robb Wilson** (M.) has been appointed Editor and Publisher of *Flying* magazine. He has been serving as Aviation Columnist on the *New York Herald Tribune.*

### PROMOTED BY U.A.C.

*Thomas B. Rhines (M.) has been promoted from Chief Development Engineer to Assistant Chief Engineer at Hamilton Standard Division, United Aircraft Corporation. Immediately upon graduating from Massachusetts Institute of Technology in 1932 with a B.S. degree, Mr. Rhines joined the Research Division of United Aircraft and within a comparatively short time was made Chief Production Engineer.*

## Members on the Move

**The purpose of this section is to provide information concerning the latest affiliations of I.A.S. members. All members are, therefore, urged to notify the News Editor of changes as soon as they occur.**

**Robert E. Abbott** (T.M.), Development Coordinator, Jacobs Aircraft Engine Company. Formerly Stress Analyst—Rotor Blades, Piasecki Helicopter Corporation.

**H. Norman Abramson** (T.M.), Project Analytical Engineer, Chance Vought Aircraft Division, United Aircraft Corporation. Formerly, Research Assistant and Graduate Student, Division of Engineering Mechanics, Stanford University.

**George Baughman** (M.), Staff Engineer, Lockheed Aircraft Corporation, Marietta, Ga. Formerly, President, Wichita Tech Council, Wichita, Kan.

**Dietrich W. Botstiber** (M.), President and General Manager, Technical Development Company, Philadelphia. Formerly, Chief Mechanical Development Engineer, Piasecki Helicopter Corporation.

**J. E. Boyce** (M.), now with Lockheed Aircraft Corporation.

**Richard P. Castle** (T.M.), Initial Project Department, A. V. Roe Canada Limited. Formerly, Design (Aircraft) Office, Avro.

**Dr. Alexander C. Charters, Jr.** (M.), now Research Consultant, Free Flight Wind Tunnels Branch, Ames Aeronautical Laboratory, N.A.C.A., Moffett Field, Calif.

**Charles H. Colvin** (F.), Director, Colvin Laboratories, 12 Court St., Morristown, N.J. Formerly, Vice-President, G. M. Giannini & Company.

**Frank T. Courtney** (M.), now Liaison Engineer, Rheem Manufacturing Company.

**P. D. Doran** (M.), Chief, Commercial Sales, Pratt & Whitney Aircraft Division, United Aircraft Corporation. Formerly, Chief, Airlines Engineering, Pratt & Whitney.

**Ralph Nicholas Du Bois** (A.F.), Chief Product Engineer, Aircraft Engine Division, Ford Motor Company. Formerly, Professor in Charge, Department of Engines, Aeronautics Institute of Technology of Brazil.

**John W. Ebert, Jr.** (M.), now Engineering Specialist, Goodyear Aircraft Corporation, The Goodyear Tire & Rubber Company.

**M. Jack Frank** (M.), Chief, Manufacturing Division, Aircraft Armaments, Inc.

(*Continued on page 62*)

### PROMOTED BY DOUGLAS

*Joseph J. Dysart (A.F.) was recently named Assistant Chief Project Engineer for the DC-6 and DC-7 series of transports. Mr. Dysart, who is a graduate of the Massachusetts Institute of Technology, joined the Douglas organization in September, 1950. Prior to that time, he had been with Pan American World Airways for 15 years, dividing the time equally between the Chief Engineer's office and Maintenance Management.*

Defense Mobilizer Charles E. Wilson addressing the Honors Night Dinner audience at the Hotel Astor, January 28.

# A Revolution in Technique

A Guest Editorial
by
**Charles E. Wilson***

"I am glad to appear before this audience to discuss the prospects and problems of defense mobilization. I do so at a time when the nation is still suffering from the attack of budgetitis that broke out when the President announced the $85,000,000,000 overall budget for the coming fiscal year.

"It is proper for me, as Director of Defense Mobilization, to say something about the budget, because the

* Director of Defense Mobilization.

lion's share of the money to be spent will be devoted to safeguarding the nation against attack. Or, more hopefully, it will be devoted to the prevention of a third world war, the cost of which would be many times greater than even the astronomical sums in the budget.

"More than $50,000,000,000 has been set aside for the military alone, and this does not include the large sums that are being spent on the development of atomic energy, nor does it include money to strengthen our friends in the Free World. If by some miracle the menace of communist imperialism were to disappear overnight, the 1952–1953 military budget could be cut by more than 75 per cent.

"The fact is that the nation is buying an insurance policy. Though the premiums are very heavy, it would be the most tragic kind of folly to drop the policy. We are buying time; I hope and believe we are buying peace; and, in the last analysis, if war should come, we are buying victory. No price is too high to assure those objectives because the alternative is unthinkable.

"The size of military expenditures in the new budget came as no surprise—though it is always human nature to be shocked when the bills come in—no surprise to anyone who has followed the course of our national policy since the invasion of Korea in June, 1950, and since the entry of Chinese Communists in the Korean war in November of the same year.

"At that time, with remarkable unanimity, the nation decided on a policy of preparedness. For 5 years, ever since World War II ended, the Free World had endured the tensions of the cold war. But Korea proved the Free World had to be ready for more than a cold war—even a third major conflict.

"It was then that the decision was made to embark upon a 3-year program of mobilization, at a cost averaging about $50,000,000,000 a year. The plans included the increase of our Armed Services to 3,500,000 men; the creation of 18 Army divisions and $2^1/_3$ Marine divisions; augmenting the Navy by de-mothballing and new construction; and the setting-up of a 95-wing Air Force.

"In the course of the last year these sights have been raised due to the continuing gravity of the international situation and to the constant study of our defense needs by the Joint Chiefs of Staff. We now propose—and the new budget takes the change into consideration—to increase the Armed Forces to 3,700,000; to build up to 21 Army divisions and 3 Marine divisions; to have a

Navy with 408 major combatant vessels in the active fleet and 16 large carrier air groups; and to enlarge the Air Force to 143 wings.

"The original program was set to continue 3 years more or less. When the Joint Chiefs decided a larger military program was necessary, some people urged that this be added at once to the current program and that a military budget alone of $85,000,000,000 be submitted to Congress—equal by itself to the overall budget presented by the President.

"Wiser counsel prevailed, however. It was realized that the impact of such a program on the civilian economy would be terrific. It was also realized that in the calendar year 1952 very little additional production would be achieved even if the $85,000,000,000 military program were adopted.

"Accordingly it was decided to proceed, as before, with a production and procurement program averaging out at about $50,000,000,000 per year but to stretch that program to 4 years or a little longer. The new program calls for a longer plateau of peak production. This plateau will now run during an 18-month period from December, 1952, to July, 1954.

"This policy grows out of lengthy and detailed discussion by the highest military and civilian mobilization officials. In terms of money, it calls for a rise in military spending from its present rate of about $3,400,000,000 a month to $4,400,000,000 in June, to $5,000,000,000 in December, and then to a high of about $5,300,000,000 during the first quarter of 1953—this peak to be maintained until the mobilization job can reasonably be considered complete.

"In deciding on this policy, your officials again rejected the idea of trying to do the mobilization job in one mighty, but brief, effort. This would have amounted to total mobilization—a goal to which the nation should not be pushed at the present juncture of world affairs.

"Total mobilization would disrupt our civilian economy; it would close down large segments of industry and business; it would throw millions out of work; it would produce mountains of obsolete and obsolescent weapons for which there is no immediate use. In short, total mobilization would be an act of hysteria to which this powerful nation has no intention of succumbing.

"So we are not altering the original 3-year plan in any marked degree, except to lengthen it to make provision for the added strength our military chieftains and statesmen have decided is necessary. There will be no sudden and violent upswing in military production with a corresponding disastrous downswing in the civilian economy. We are simply going to maintain our production peak a while longer than originally planned.

"Aside from general factors that underlie this policy, it accords with practical considerations, such as the limits on our supplies of strategic materials, the time needed to design and manufacture new and special types of machine tools, and the time needed to perfect the fantastic new weapons, along with the complex electronic devices that are necessary to make them function properly.

"Extending the program by one year will mean real improvement in many weapons, particularly the newest types, because we will have more time to incorporate the significant changes in design which are coming along every day in the week. The weapons, by being newer, will take longer to become obsolete. For this reason, the taxpayer will get a lot more security for his tax dollar. This is also for the reason that compressing the higher military requirements into the original 3-year plan would mean higher costs.

"When we reach the production peak at the end of this year, we will be better able to sustain it for the required period because we will have a broader industrial base. One of the vital decisions made after the Korean war—its results will become apparent this year—was to expand our capacity in steel, aluminum, electric power, chemicals, petroleum, and other fundamentals of modern industrial life. A good part of this expansion is already in place.

"Indeed, one of the main reasons for our material shortages is the fact that a vast amount of materials has been going into basic expansion. It takes steel to build new steel plants. It takes steel to build new aluminum plants. It takes steel and copper to make new electric generators. It takes steel for oil-drilling and refining equipment.

"That's where a lot of our supplies have been going in the past year. We are beginning to draw dividends from this investment, and they will become bigger and bigger as time goes on. We will have increased our steel capacity by 20 per cent, our aluminum capacity by 100 per cent, our electric power capacity by 40 per cent, and so on down the line.

"It must strike fear into the heart of the enemy to realize how much more powerful the United States will become under the impact of defense mobilization. Our country astounded the world by its production miracles in World War II. It even drew a reluctant tribute from Joseph Stalin, who said that without United States machines, the United Nations could never have won the war. But before long we will be able, if necessary, to surpass the production records of the last war.

"In fact, because of the expansion program, we can look forward to the easing of controls on materials. The pinch is being felt strongly this year because the expansion program and the arms program are both rising to their peaks. But the former will be completed first and then will add to our flow of materials.

"Already, restrictions have been removed from rubber, and it will not be long before a balance between supply and demand will be achieved in certain types of steel. I wish I could say the same about copper, but the outlook there will not improve for a long time nor will it quickly improve with regard to some other metals, particularly alloys.

"When I mention alloys, it causes me to think of jet engines and that, in turn, causes me to reach for the aspirin. Some of the worst headaches of defense

*(Left)* Allan D. Emil, legal adviser to the Institute, acknowledges receipt of the Special Honorary Membership presented to him by the I.A.S. Council. *(Center)* The two Honorary Fellows for 1951, J. H. Parkin and Leroy R. Grumman, receive congratulations from I.A.S. President Rear Adm. L. B. Richardson and The Honorable Charles E. Wilson, Director, Office of Defense Mobilization. *(Right)* Leroy Grumman expresses his appreciation for his selection as 1951 American Honorary Fellow.

mobilization have been produced by the brilliant men in this room, whose advances in the art and science of airplane construction have created the most difficult supply problems.

"Nothing short of a revolution in fighting aircraft has occurred since the last war. It seems only yesterday that we used to read about the exploits of the Flying Fortress, the B-17, and the Superfortress, the B-29. It is hard to realize that these great airplanes have already become obsolete.

"Not a single United States jet airplane saw action in World War II, though the Germans foretold the future in turning out the Messerschmidt 262, which gave us plenty of anxiety before the war ended. We have learned many things from Korea, and one of them is that the piston-engine plane can no longer be considered a first-line fighting aircraft. We have learned, too, from the MIG-15 that flies in great numbers in Korean skies that we have some way to go before we can clearly establish jet supremacy in quality and numbers. However, our F-86, under the skillful handling of our magnificent pilots, has shown to real advantage against the MIG, the latest score for air-to-air combat being 158 MIG-15's destroyed as against 20 F-86's.

"The jet age might also be called the high-temperature age. This fact profoundly distinguishes the materials and metallurgical problems that exist today as compared with those that existed during World War II. Whereas air superiority in World War II was a function of the perfection of mechanical devices in the form of reciprocating engines, it is now a function of temperatures and pressures that can be withstood by metals.

"In the last war, maximum efficiency in an aircraft was guaranteed when a piston was made to move through a cylinder with a minimum of limitations imposed by fundamental laws of friction, mass, and human perfection in an assembly of thousands of intricate parts. In this age, there are fewer such limitations because thrust in jet engines is largely a function of temperature and is limited, therefore, only by the capacity of materials to withstand high temperatures. Hence, major air superiority is a product of the temperatures that the physicist can induce, coupled with the materials that the metallurgist and ceramist can develop to withstand the high temperatures.

"This condition has forced us to use materials such as columbium, cobalt, tungsten, cerium, and others that were largely academic curiosities prior to the recent demands of jet aircraft. Most of these metals are found in useful quantities only in foreign lands; their extraction from ores is immensely complicated by comparison with the well-known metals such as iron and copper; their melting points are so high that they are very difficult to alloy with a base metal such as iron. Along with their high-temperature properties goes brittleness that makes forming difficult—all this plus the fact that high temperature-resisting, hard, brittle materials are inherently difficult to weld. The utilization of these exceptional materials has been a limiting factor in jet engine planning.

"We have also had to look to the day when thrust required to guarantee air superiority will require temperatures that cannot be tolerated by metals exclusively. We are investigating the use of ceramic materials either alone or in combination with metals. These materials extend the tolerable temperature range beyond the most temperature-resistant metals. Again, you are faced with immensely difficult industrial procedures unlike anything ever before encountered on our production lines.

"The men in this audience, of course, are aware of these technical problems and of the fact that radical changes in aircraft construction cannot be accomplished overnight. But I think there is insufficient public understanding of necessary delays in turning from the old-type planes to the new. This year the Navy will fly a jet plane that has been in the making since 1946—6 long years ago.

(*Continued on page 55*)

# DECELERON

## —A Feature of the F-89 Scorpion Control System

by Boyd Richardson*

CONSTANT IMPROVEMENT in aerodynamic and power-plant design has reduced the margin between the normal operating speeds and maximum permissible speeds of modern fighter-interceptor aircraft to the point where some form of aerodynamic brake has become necessary. This is particularly true under circumstances where the combination of high power output and low drag may result in sudden acceleration to speeds at which dangerous compressibility effects arise, particularly in the high-altitude ranges of the modern interceptor airplane. In addition, present-day combat requirements are such that one of the most important uses for speed brakes is to achieve rapid deceleration after overtake at high speed in order to provide more time for firing.

Although the design and use of speed brakes are not new, their application to modern fighter and interceptor aircraft as a necessary element of control is of fairly recent origin. Unique among the many types of speed brake is the deceleron, developed by Northrop Aircraft engineers for use on the F-89 Scorpion.

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* Service Engineer, Northrop Aircraft, Inc.

The deceleron was originally developed during the design of the first Northrop all-wing airplane and was used in successive all-wing designs culminating in the Northrop YB-49 eight-jet flying wing bomber. Essentially, decelerons are speed brakes formed when the aileron is split transversely at the trailing edge.

The Northrop N9M, a one-third flying scale model of the XB-35 flying wing bomber, was the first airplane on which the deceleron was used. On that airplane, it functioned as a drag rudder rather than as a speed brake and performed a similar role on the XB-35 and YB-49 flying wings that followed the successful testing of the N9M. It is worthy of note that all of these airplanes incorporated full power-control systems, which simplified the mechanical and structural problems inherent in the design of a speed-brake integral with a major flight-control surface.

The Scorpion was designed following the successful testing of the flying wing airplanes and was the first Northrop airplane to use the deceleron principle exclusively as a speed brake.

The problems of dive recovery and deceleration during high-speed maneuvers have been the subject

of aerodynamic research for a number of years but have been of particular importance since the development of production aircraft capable of approaching or exceeding sonic speeds. Aerodynamic history has recorded the development of a multitude of speed-brake and spoiler mechanisms, most of which were designed to meet the needs of a specific aircraft type and which were lacking in effectiveness because of limited design experience and research data. In addition, the mechanical limitations inherent in aircraft-control-system design before the successful development of power-control systems made it difficult for the design engineer to incorporate an efficient decelerating component within the aircraft surface-control system.

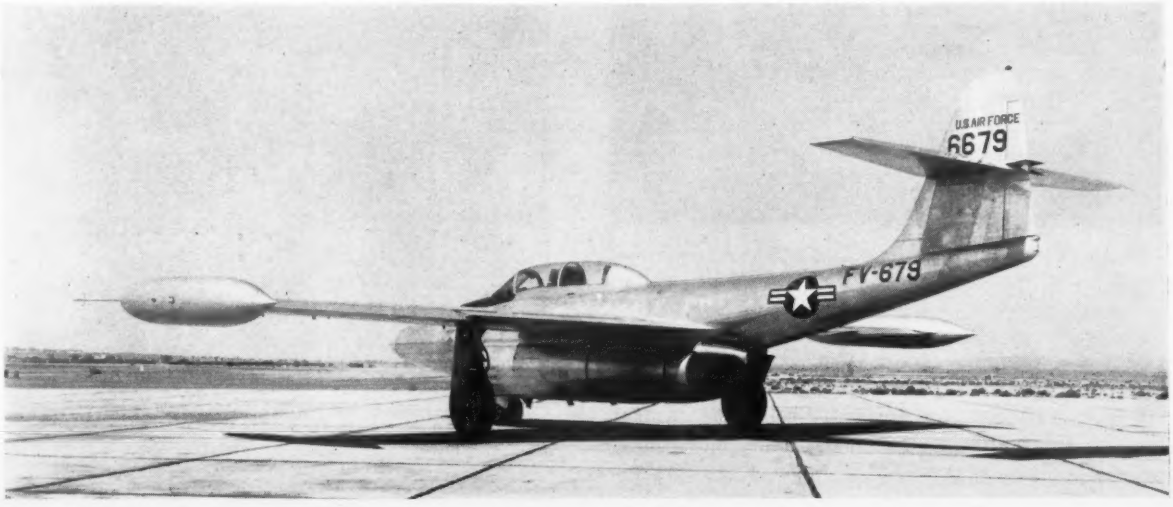
The first attempt to combine an aerodynamic brake with flight-control surfaces was made as far back as 1931. In that year the Northrop-designed Beta, which employed a split aileron-flap type of control, was developed. In 1936, a split-flap dive brake was successfully used on the Northrop-designed BT-1 and later on the Douglas SBD series during World War II. Many other types of deceleration mechanisms were engineered and tested during this period, most of them designed as separate components, operated independently of the aircraft flight-control system. Even today, many of our latest aircraft types use speed brakes—principally of the fuselage flap type—which are entirely independent of the surface controls.

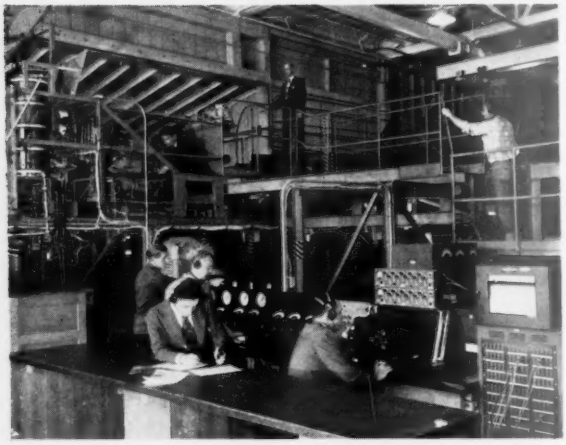
Now that speed brakes have become an indispensable part of fighter-interceptor aircraft, pilots are discovering many new applications for their use in combat maneuvering. It is through these recent experiments that the versatility and value of the deceleron has come to light.

In 1948, Northrop constructed a full-scale control system test stand that exactly duplicated the Scorpion's complete control system, with every component placed in the same spatial relationship that it occupies in the airplane. Control system tests have been conducted almost continuously since its completion early in 1949, and, as a result of these tests, significant design improvements have been made in both functional and mechanical operation. Sufficient data have been accumulated, as a result of many different types of tests conducted over a two-year period, to indicate that the Scorpion's control system is entirely reliable and completely adequate from the standpoint of design requirements. Much credit for the success of the deceleron must be given to the concurrent development of the Scorpion's full power-control system, for, without it, the design of the deceleron from a structural and mechanical point of view would have been enormously complicated. Moreover, the use of an irreversible power-control system simplified design problems by eliminating the need for mass balancing of the combination aileron-speed brake.

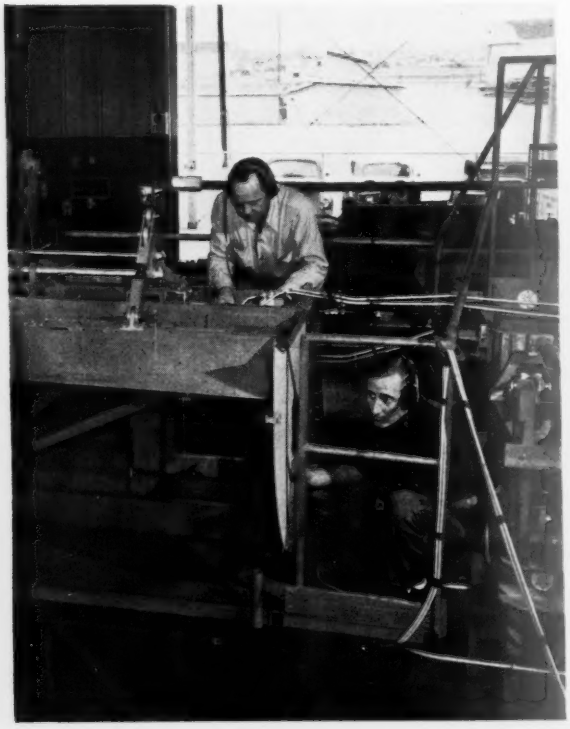
The Scorpion's control system is full power-operated, which means that no stick or rudder pedal forces are transmitted directly to any control surface. Since air loads on the control surfaces cannot be felt by the pilot at the control stick or rudder pedals, a simulated air load, or "feel," is mechanically provided. Elevator and aileron trim control is obtained by reducing loads on the stick to zero. When trim is necessary, the control stick is moved in the proper direction to stabilize the airplane. Actuation of a four-way switch on the control stick then reduces stick forces to zero and leaves the ailerons and elevators in a deflected position. The stick remains deflected in the new trim position. Under normal conditions, no provision is made for rudder trim, since the yaw stabilizer takes care of momentary deflections. A safety wired rudder trim knob is provided on the pilot's pedestal and may be used for rudder trim under emergency conditions.

This view of the U.S. Air Force's Northrop Scorpion F-89 shows the decelerons—combination ailerons and speed brakes—in closed position. The ailerons split at the trailing edge to form speed brakes.





All the elements of flight control from take-off to let-down can be simulated, recorded, and analyzed by this power-control test stand built by Northrop Aircraft test laboratory engineers in developing the full power-control system used on the Scorpion F-89 all-weather interceptor. Known as "Iron Ike," the test stand expedited, at considerable savings in time and costs, development of the F-89 control system. Man in light suit, upper left, mans cockpit controls. Engineer in dark suit, upper left, supervises test, prescribing maneuvers for "flight" plan under study. Engineers in foreground monitor recording equipment.



Maximum available hinge moments and minimum increments of movement—vital data in any aircraft control system—are checked by technicians.

The irreversibility factor is an important feature of the Scorpion's full-power hydraulic control system. Air loads on the control surfaces resulting from gusts are not transmitted to the pilot's stick and rudder pedals, and, for that reason, control of the airplane is made easier and smoother. One of the most important advantages of irreversibility is the elimination of aileron buzz, a high-speed phenomenon common to airplanes that do not employ an irreversible control system.

Although the deceleron is an integral part of the aileron and, as such, can be considered a component of the Scorpion's flight-control system, it is controlled by a lever in the pilot's cockpit through a separate system.

The deceleron is part of a combined surface control that functions both as an aileron and as a speed brake. Each aileron splits transversely at a point just behind the aileron leading edge and opens along hinge lines parallel to the aileron hinge line. When the two surfaces that form the deceleron are closed, the entire unit acts as a conventional aileron. When the surfaces are open, they form an aerodynamic brake, or deceleron. An important aspect of the operation is the fact that aileron or deceleron movement in any direction can occur simultaneously. In other words, the opening or closing of the deceleron has no effect on full up or down travel of the aileron.

Of more value from the standpoint of performance is the relief from wing dropping tendencies—common to fighter-interceptor aircraft at high speeds—obtained by use of the deceleron. Numerous flight tests have been made, and results indicate that decelerons com-

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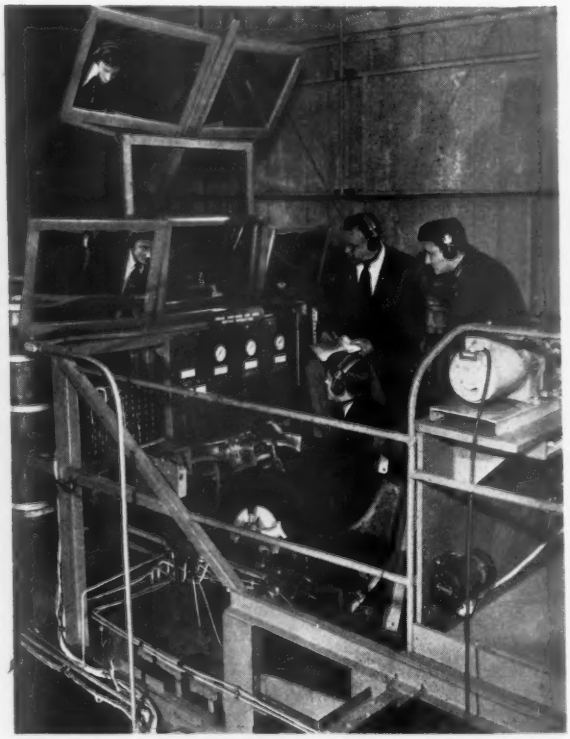

This is the cockpit from which engineers control "Iron Ike" on simulated flights. Mirrors enable man at stick to follow movement of controls and actions of other members of test crew. Throat mikes and headphones enable crew members to coordinate. No effort was made to simulate instrument panel of F-89. Instruments shown are essential only to operation of test stand.

# Reduction of Gun-Gas Explosion Hazard in Combat Aircraft

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## Introduction

IT IS PERHAPS not a well-known fact to engineers and scientists that the residual gases in the vicinity of functioning machine guns are in themselves highly explosive. When mixed in the proper proportion with air and exposed to a suitable source of ignition, these gases are capable of producing violent explosions. These gases, present in the gun compartment of a combat-type aircraft, may result in an explosion producing considerable damage. The N.A.D.C. has designed a gas-detection apparatus suitable for investigating this condition and has evolved tentative design criteria intended to aid the air-frame manufacturer and designer.

## General

The composition of gun-propellant powders has been the subject of much experimentation throughout the history of modern warfare. It was learned early in the development of these powders that the ratio of the combustible material to the oxidant had an important influence upon the overall characteristics of a given powder. The maximum temperature that the gun barrel may safely withstand, the muzzle velocity of the projectile, and the desired rate of burning are but a few of the factors that determine this ratio. In modern gun-propellant powders, the ratio is such that there is an excess of fuel and a deficiency of oxidant. For this reason, the gases leaving the muzzle after a gun has been fired contain a considerable quantity of combustible material, rich in hydrogen and carbon monoxide. When diluted with air in the proper proportion, the mixture may be ignited by a suitable source of ignition and may produce a violent explosion. Some of these explosions occur in front of the muzzle and account for the bright "secondary flashes" that may be observed in front of combat-type aircraft during bursts of machine-gun fire.

It is important to note that not all of the gases are exhausted via the muzzle. In gas-operated guns employing an actuating cylinder, some of the gas flows into the cylinder to operate a piston that initiates the opening of the breech. Because of the high pressures involved, some of the gas leaks from the mechanism. In guns operated directly by gas pressure within the barrel, commonly referred to as blow-back guns, some gas is necessarily ejected with the cartridge case. Recoil-operated guns also permit gas to escape through the breech. Thus, it is easily seen that a considerable quantity of combustible gas is vented into the gun compartment of a combat aircraft.

The composition of gun gas varies to some extent, depending upon the composition of the particular lot of powder and upon the point of ejection from the gun. The following is a typical dry analysis:

| | |
|---|---|
| Carbon dioxide ($CO_2$) | 14 per cent |
| Hydrogen ($H_2$) | 19 per cent |
| Carbon monoxide (CO) | 52 per cent |
| Methane ($CH_4$) | 1 per cent |
| Nitrogen ($N_2$) | 14 per cent |

The gas also contains water vapor that condenses during expansion and cooling. Since it is obscured by flame and smoke, the condensation is not usually observed.

A wide range of gas-air mixture ratios is explosive. The limiting ratios for any gas-air mixture are conventionally designated as the lower explosive limit and the upper explosive limit. The lower explosive limit is the minimum percentage of gas in a homogeneous mixture of gas and air which will permit propagation of an explosion from a suitable source of ignition. Mixtures richer than the upper explosive limit will not burn. The limits for hydrogen, for example, are 4.1 per cent and 74 per cent and for carbon monoxide 12.5 per cent and 74 per cent. Experiments conducted by the Bureau of Mines indicated the average value of the lower explosive limit for a group of samples of dry gun gas to be 11.3 per cent at sea level. The lower explosive limit decreases slightly at higher altitudes.

Gun gas burns with a bright yellow flame. It is richer in combustibles than blast furnace gas, being approximately equivalent to producer gas in this respect. The gun-gas explosion potential increases as the lower explosive limit is exceeded and achieves a maximum value at a concentration between 300 and 400 per cent of the lower explosive limit. In general, explosions occurring at high altitudes are less violent than those that occur at sea level. This is because less energy is released by the lower-density mixtures, and, consequently, a smaller differential pressure is produced.

Gun gas will not explode unless it is exposed to a suitable source of ignition. In aircraft gun installations there are many such sources. The 20-mm. gun, M3, for example, can itself initiate the explosions, since certain mechanical parts of the assembly become ex-

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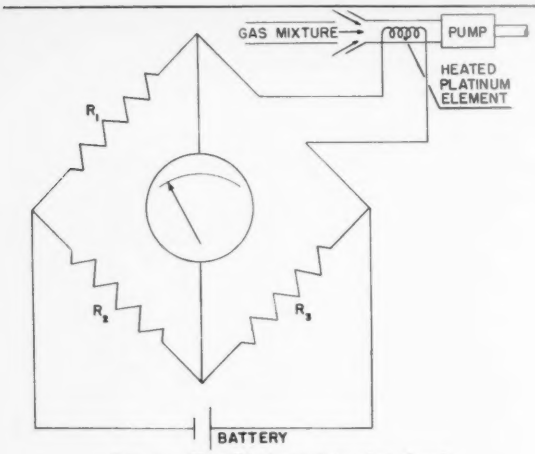



FIG. 1. Simplified gas-detection circuit.

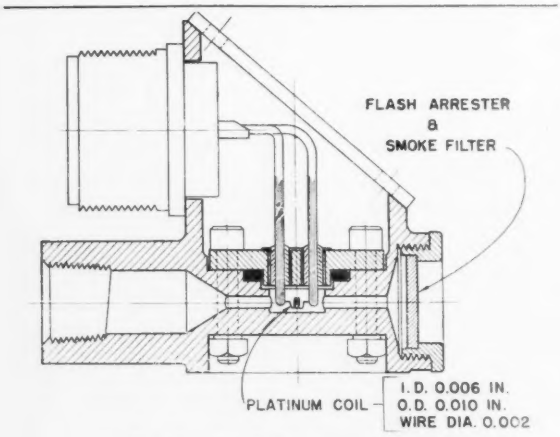



FIG. 2. N.A.D.C. gas-sensing unit.

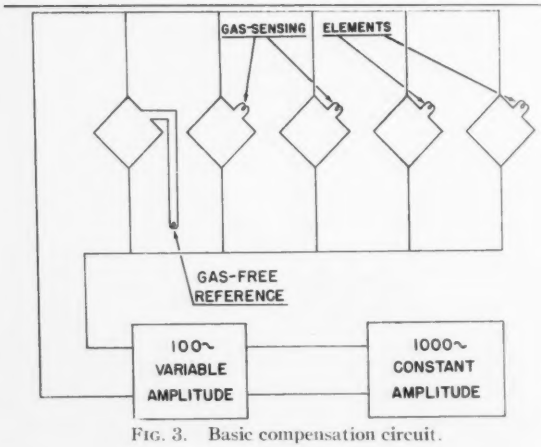



FIG. 3. Basic compensation circuit.

tremely hot during long bursts. Other sources of ignition include incandescent particles or flames traveling from the barrel into the breech area after cartridge case ejection, contact points in electrically fired guns, gun-circuit relays, components in electronic equipment, damaged gun or feed mechanism heaters, cracks or punctures in blast tubes, and enemy projectiles.

## THE N.A.D.C. GUN-GAS DETECTOR

In order properly to investigate the presence, concentration, and distribution of gun gas, it is evident that an instrument is required possessing certain characteristics not ordinarily found in commercial-type gas detectors. It must have a rapid time response, since the gas concentration in certain gun installations may rise to a dangerously high level in less than one second. In addition, it must have some type of compensation in order to operate satisfactorily over the wide range of temperature and pressure encountered by combat aircraft.

The N.A.D.C. gun-gas detector operates on the principle that a heated platinum filament will undergo a change in temperature when exposed to a mixture of combustible gas and air. The underlying physical principle involves catalytic agency that causes the combustible gas to burn, thus generating heat. The increase in temperature produces a corresponding change in electrical resistance, and, if the platinum filament is connected as one arm of a Wheatstone bridge, as shown in Fig. 1, the change in resistance will cause a variation in the output voltage. A suitable calibration may be made, relating the gas concentration to the magnitude of the output voltage.

In order to achieve high-speed response, the gas-sensing element must, of necessity, be of small mass and possess high thermal conductivity. In addition, the gas mixture must be presented to it without passing through a delay network of pipes or hoses. In order to meet these requirements, the N.A.D.C. unit was designed of platinum wire 0.002 in. in diameter, wound as a helix with an inside diameter of 0.006 in. and a length of 0.090 in. It is mounted in a small chamber having a volume of approximately 0.0025 cu.in., located close to the point at which the gas mixture enters the system. The gas and air mixture is drawn through the chamber by means of a vacuum pump, and the flow is regulated by a capillary tube so that the mixture is replaced approximately every one-tenth second. A porous bronze shield separates the platinum element from the source of gas to prevent propagation of an explosion back to the source and also serves as a filter to prevent solid particles from entering the system. The arrangement is shown in Fig. 2.

The surface temperature of the platinum element determines in large measure the degree of sensitivity to a given mixture of gas and air. It is therefore important that this temperature be regulated and maintained within close limits. Since the density of the air entering the element decreases with altitude, conduction of heat from the element is correspondingly decreased. On the other hand, the ambient temperature decreases with altitude, and heat losses from the element are correspondingly increased. A regulating circuit is therefore required to maintain the platinum element at constant temperature. A Wheatstone bridge containing a reference platinum element, located in a gas-free area, is associated with a low-frequency oscillator

that has been designed to maintain the resistance (and, hence, the temperature) of the platinum element as nearly constant as possible. The output voltage of this oscillator is then applied to other Wheatstone bridges, each containing a gas-detecting platinum element. In this manner, each platinum element operates at constant temperature and is unaffected by changes in air density or ambient temperature.

An additional oscillator, providing a constant-amplitude, high-frequency voltage, is simultaneously applied to the Wheatstone bridges, as shown in Fig. 3. When gas is introduced to the system, the platinum elements exposed to the gas increase in temperature, unbalancing their respective Wheatstone bridges. The reference platinum element associated with the low-frequency oscillator is shielded from the gas, however, so the regulating action of the low-frequency oscillator is unaffected. Thus, there is established a gas-free reference level of temperature; any variation in the high-frequency output voltage may be measured as a deviation from this level and is independent of the ambient temperature and air density. A relay circuit may be adjusted to render the guns inoperative should the gas concentration at any of the gas-sensing elements exceed a predetermined level.

For ease in installation, the equipment is built in several small units. The pilot's control box (Fig. 4) arms the equipment and contains the meters on which the gas concentrations are presented to the pilot. The amplifier (Fig. 5) contains the electronic circuits and adjustment controls. A dynamotor supplies high-voltage power for the electronic circuits, and a vacuum pump unit provides a pressure differential across the platinum elements. A heated manifold houses the capillary air-flow regulators, one for each gas channel. A recording oscillograph is usually associated with the gas detector to obtain a permanent record of each flight.

## Two General Approaches to the Problem of Eliminating Gun-Gas Hazards

The problem of eliminating the danger of gun-gas explosions can be solved by two general approaches. The first is to determine suitable means for ventilating the compartment in order to reduce the major part of the combustible mixture to a concentration below the lower explosive limit. This will be discussed at some length later. The second involves various means to determine suitable methods for preventing the gases from damaging the aircraft. Among such methods are the following:

(a) Controlled burning or exploding of gun gas before it can accumulate in sufficient quantity to cause a damaging explosion.

(b) Use of inert diluents or quenchants.

(c) Exclusion of oxygen from the gun compartment.

(d) Use of gun-gas adsorbents, catalysts, or flame-guard screens.

(e) Use of mechanical devices, such as spring-loaded doors, to relieve the pressure of the explosion.

Several methods have been considered for accomplishing controlled combustion of gun gases. These include the use of sparking devices and glow coils. Sparking devices are, in general, more reliable than glow coils, and they have the advantage that no preheating is required. A disadvantage, however, is the radio noise that they introduce; while it is unlikely that the radio will be in use during firing bursts, the sparking devices could cause interference with automatic gun-aiming equipment, if used. It should be noted that ignition devices are capable of exploding fuel vapors as well as gun gas, and therefore present a hazard in the event of damage to the fuel system. Also, there is no assurance that a gas pocket may not grow to a dangerous size at a point remote from the ignitor and then drift toward it. Further, since there may be a number of sources of gun gas at which the concentrations may vary over a wide range, and since the space and time distribution of these concentrations may vary widely in the same aircraft under different flight conditions, it is generally impossible to ensure reliability of this system unless a large number of spark ignitors is distributed throughout the compartment. The accept-

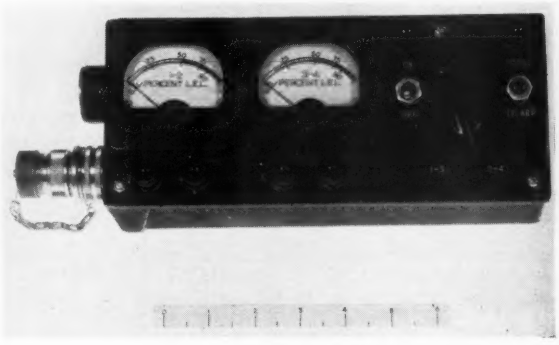


Fig. 4. Control box.

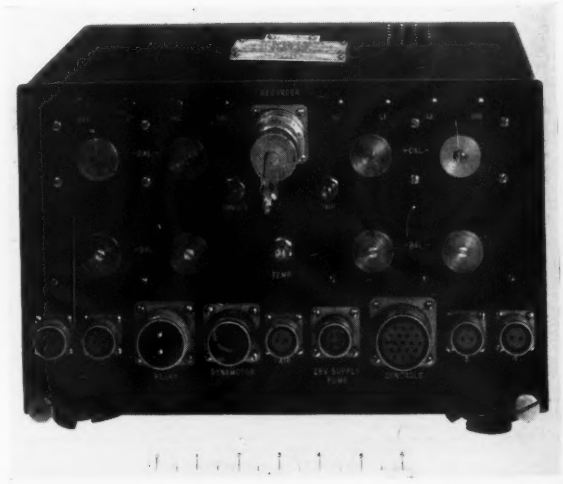


Fig. 5. Amplifier.

ability of devices that might add to accident and crash hazards is open to serious question.

Inert diluents or quenchants, such as carbon dioxide, methyl chloride, and nitrogen, neither burn nor support combustion. Added to a mixture of combustible gas and air, they raise the lower explosive limit and reduce the intensity of the explosions. However, it is usually necessary to add large amounts of these substances in order to effect an appreciable decrease in the tendency of the mixture to explode. (Considerable data on the effect of carbon dioxide and nitrogen upon the explosibility of hydrogen-air and carbon monoxide-air mixtures may be found in Bureau of Mines Bulletin No. 279, *Limits of Inflammability of Gases and Vapors.*)

The use of quenchants involves the weight penalty of container, valves, and control system. The arrangement must not be of the one-shot type. It must be so operated that it will open and close as each successive burst is fired. This system imposes logistic penalties and increases rearming time between successive combat flights. The use of dust-type quenching agents, such as are used in mines, appears wholly impracticable.

The exclusion of oxygen from the gun compartment would effectively prevent explosions. Such exclusion could be accomplished by ducting oxygen-deficient exhaust gas from certain types of engines or from space heaters into the gun compartment. (This method might be considered to be an alternate form of the quenchant method.) Operation of the exhaust-gas ducting system for a period of time preceding the firing of the guns would, in a fairly tight gun compartment, replace most of the oxygen with which the gun gas might otherwise combine. Unfortunately, however, since engine and heater exhaust gases contain a considerable amount of moisture, it would be necessary to precool them below the temperature of the guns and other equipment in the compartment to prevent the formation of ice. Also, precautions would have to be taken to prevent the entry of carbon monoxide into the cockpit.

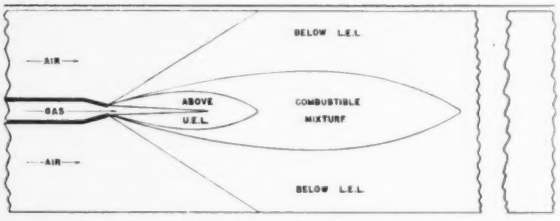



FIG. 6. Idealized gas-air mixture diagram.

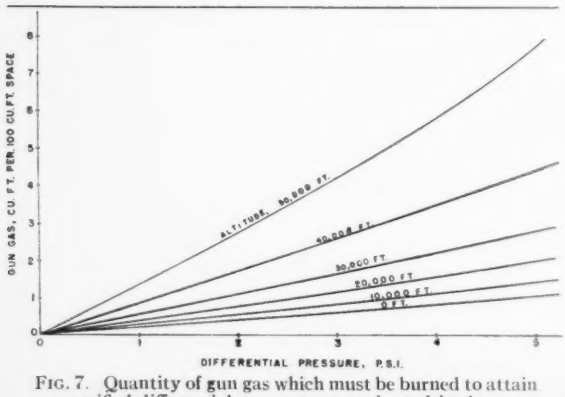



FIG. 7. Quantity of gun gas which must be burned to attain specified differential pressures at various altitudes.

In general, catalysts and adsorbents are considered to be impractical. Their weight and bulk, the probability that they might react too slowly for the rate of gun-gas emission, particularly at low temperatures, the possibility that they might be prematurely deactivated or "poisoned," and the probable requirement for blowers to direct the gas to the activated surfaces, together with the logistic and rearmament time implications, render of doubtful value any search for a solution among these materials.

Similarly, the use of explosion-damping screens appears to be impractical, particularly since the locations of ignition points are likely to be unpredictable and since the handling of the bulky multiple layers of screens would prohibitively delay rearming of the guns between combat flights.

Mechanical devices, such as spring-loaded doors, intended to relieve the pressure produced by an explosion, have proved to be impractical since they react too slowly. The rate of increase of pressure within a gun compartment is so rapid that structural seams and members fail before the inertia of a spring-loaded door has allowed it to move appreciably.

Gun gas may be ducted away from certain regions about the guns, provided suitable low-pressure areas exist outside the aircraft. The lead-out lines should be protected by shutters and actuators in order to prevent cold air from circulating around the gun compartment during prefiring flight. However, since the construction and operation of guns make it difficult, if not impossible, to capture all the gases before they have been afforded an opportunity to mix with air, this solution offers only marginal results unless used in conjunction with a ventilating system, in which case the amount of ventilating air may be somewhat reduced.

## The Ventilation Approach to the Problem of Eliminating Gun-Gas Hazards

It appears that the simplest method of solving the gun-gas problem from the structural and safety standpoint has been that of providing adequate ventilating air and distributing it properly. This will now be discussed in more detail.

Let us consider for a moment a simple illustration of what occurs during firing of the guns. Instead of the complex aircraft structure, consider a small tube discharging combustible gas into a larger coaxial tube through which fresh air is passing at a lower velocity in the same direction, as shown in Fig. 6. Beyond the end of the small tube there will be a cone of undiluted gas. Surrounding this cone there will be a region in

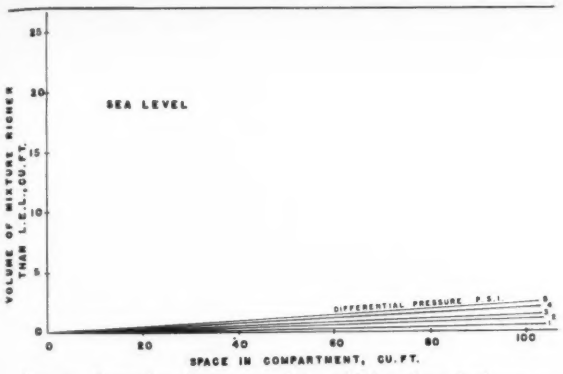



FIG. 8. Quantity of gun-gas mixture (richer than the lower explosive limit) which may be burned without exceeding the specified differential pressure.

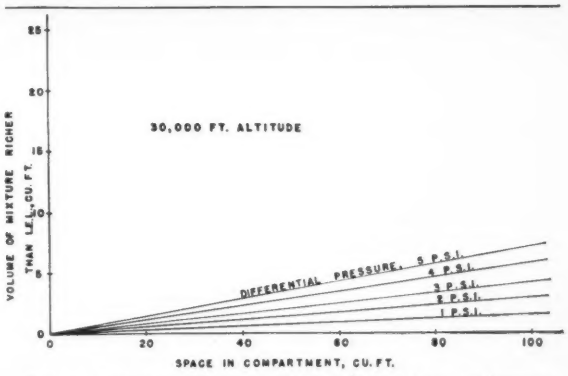



FIG. 9. Quantity of gun-gas mixture (richer than the lower explosive limit) which may be burned without exceeding the specified differential pressure.

which the gas is partly diluted with air, but above the upper explosive limit. There will be a larger region in which the mixture is within the explosive range; beyond that a region in which the mixture is below the lower explosive limit; and an outer region in which there is uncontaminated air. Similar conditions exist in gun compartments. Regardless of the amount of ventilation, there will always exist some regions containing explosive mixtures during firing of the guns.

If ventilation is to be used as the solution to the problem, then two principal conditions must be established. First, sufficient uncontaminated ventilating air must be supplied to maintain the average concentration of gas well below the lower explosive limit. Second, this ventilating air must be quickly and adequately mixed with the gas as it flows from the gun so as to dilute it below the lower explosive limit and to avoid the formation of any considerable volume of combustible mixture.

Computations have been made of the differential pressures that may be produced by explosions under conditions favorable to complete combustion. It may be assumed that, under laboratory conditions, if a uniform mixture that is slightly above the lower explosive limit is ignited, it may be burned completely. If the combustion should occur instantaneously, then a maximum differential pressure of approximately 45 lbs. per sq.in. would result if the gases were at sea-level conditions. At 50,000 ft., the differential pressure would be only about 7 lbs. per sq.in. If the average concentration of gas were only 50 per cent of the lower explosive limit and complete combustion should occur, then the differential pressure would be approximately one-half the values given above. Such conditions could exist in a gun compartment where the gas discharged from the guns is poorly mixed with the ventilating air, allowing large volumes of explosive mixture to form. (The term "average concentration" as used above is defined as the ratio of the rate of flow of combustible gas discharged from the guns directly into the compartment to the rate of flow of ventilating air.)

It is evident from the pressures indicated above that only a small fraction of the gun gas within the compartment at a given time can be permitted to form mixtures

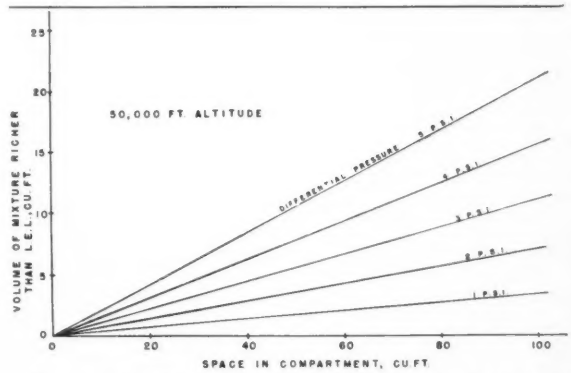



FIG. 10. Quantity of gun-gas mixture (richer than the lower explosive limit) which may be burned without exceeding the specified differential pressure.

within the explosive range. Mixing with the ventilating air must be so rapid that not more than 20 per cent of the combustible gas within the compartment exist as mixtures within the explosive range at any one instant. As a result of calculations of the mixing which can be anticipated in practice, it is indicated that the average concentration probably cannot be permitted to exceed 50 per cent of the lower explosive limit. Even in this case, good mixing of the gun gas with the ventilating air is necessary. It has been stated in the "Guide" of the American Society of Heating and Ventilating Engineers that safe practice limits the concentration of inflammable gases in buildings to 20 or 25 per cent of the lower explosive limit. It is possible that such low concentrations may not be necessary in an airplane, provided that thorough mixing with ventilating air is achieved.

In an attempt to provide tentative criteria for safe conditions of gun-gas concentration within gun compartments, several charts have been prepared as a guide. They are based on some simplifying assumptions to make the computations possible. Experimental work is under way to verify these assumptions or to provide more accurate empirical data.

Fig. 7 shows the amount of gas in a combustible mixture which will produce the range of pressure differentials shown at the specified altitudes, when burned

quickly and completely. These data are based on theory well supported by experiment.

Figs. 8, 9, and 10 are based on the data of Fig. 7 and show the volume of combustible gas mixture (richer than the lower explosive limit) which can be allowed in gun compartments of a range of sizes without exceeding the specified differential pressures when ignited. In each case, the volume must be that of the compartment, exclusive of the space occupied by the guns, other equipment, or structure.

When testing the gun compartment, the N.A.D.C. gas detector can be used to establish the volume within which the combustible gas concentration exceeds the lower explosive limit. The graphs will then indicate the differential pressure that may occur if the gas should explode.

In order to simplify the computation, it has been assumed that, once the explosion is initiated, violent mixing will take place. Some of the gas above the upper explosive limit will be diluted to an explosive mixture. Some of the explosive mixture will be diluted below the lower explosive limit, and the concentration of some of the mixture below the lower explosive limit will be increased into the explosive range. It has been assumed for simplicity, however, that all of the gas originally existing above the upper explosive limit will be burned along with that in the explosive range and that none of the gas originally below the lower explosive limit will be burned. This seems to be a reasonable and safe assumption.

As a convenience in estimating the dimensions of the space containing a gas mixture above the lower explosive limit which are allowable under specific conditions, Figs. 11, 12, and 13 have been prepared. It was assumed in preparing these graphs that an envelope enclosing all gas mixtures richer than the lower explosive limit would be a figure of revolution having the cross section shown. Since the symmetrical shape will probably not exist under actual conditions, plotted values of radius serve only as a guide.

Incomplete tests indicate that the amount of gas discharged into a gun compartment, not including muzzle gas, is of the order of 1 lb. per min. per gun. If the ventilating air should be contaminated with muzzle gas, then the amount of gas which it contains must be added to that discharged from the guns into the compartment when determining the average concentration.

Fig. 14 shows the amount of uncontaminated air required to produce a range of values of average concentration. Fig. 15 is of more casual interest. While the volume of air supplied per minute decreases as altitude increases, the allowable volume of combustible mixture increases for a given differential pressure.

The net result, as altitude is increased, is only a small change in the differential pressure with a given ventilating system, after steady conditions are established. However, an explosive condition is reached sooner at higher altitudes. (When firing guns at an altitude of 20,000 ft., under a given set of conditions, the concentration of gun gas will reach the lower explosive limit in about half the time it would take at an altitude of 2,000 ft.)

The following summarizes the requirements for adequate ventilation of gun compartments. First, sufficient air must be supplied to maintain the average concentration of combustible gas well below the lower explosive limit, probably of the order of 50 per cent of the lower explosive limit. Second, this air must be

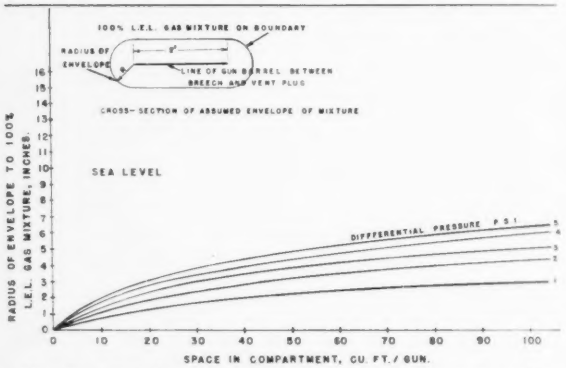

100% L.E.L. GAS MIXTURE ON BOUNDARY
RADIUS OF ENVELOPE
8'
LINE OF GUN BARREL BETWEEN BREECH AND VENT PLUG
CROSS-SECTION OF ASSUMED ENVELOPE OF MIXTURE
SEA LEVEL
DIFFERENTIAL PRESSURE P.S.I.
RADIUS OF ENVELOPE TO 100% L.E.L. GAS MIXTURE, INCHES
SPACE IN COMPARTMENT, CU. FT./ GUN.

FIG. 11. Relation between the radius of an assumed envelope containing a gas mixture richer than the lower explosive limit and the differential pressure developed by burning the gas in a compartment of specified volume.

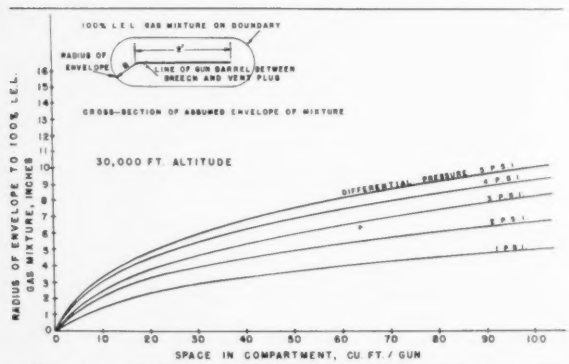

100% L.E.L. GAS MIXTURE ON BOUNDARY
RADIUS OF ENVELOPE
8'
LINE OF GUN BARREL BETWEEN BREECH AND VENT PLUG
CROSS-SECTION OF ASSUMED ENVELOPE OF MIXTURE
30,000 FT. ALTITUDE
DIFFERENTIAL PRESSURE 5 P.S.I.
4 P.S.I.
3 P.S.I.
2 P.S.I.
1 P.S.I.
RADIUS OF ENVELOPE TO 100% L.E.L. GAS MIXTURE, INCHES
SPACE IN COMPARTMENT, CU. FT./ GUN

FIG. 12. Relation between the radius of an assumed envelope containing a gas mixture richer than the lower explosive limit and the differential pressure developed by burning the gas in a compartment of specified volume.

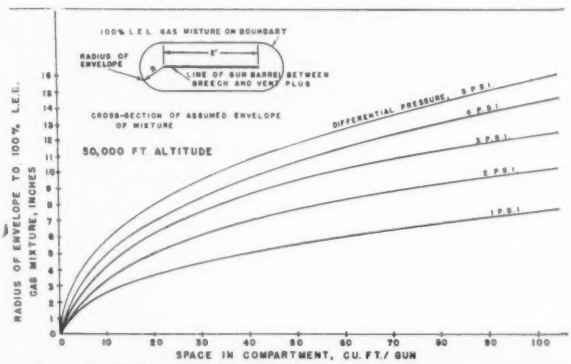

100% L.E.L. GAS MIXTURE ON BOUNDARY
RADIUS OF ENVELOPE
8'
LINE OF GUN BARREL BETWEEN BREECH AND VENT PLUG
CROSS-SECTION OF ASSUMED ENVELOPE OF MIXTURE
50,000 FT. ALTITUDE
DIFFERENTIAL PRESSURE, 5 P.S.I.
4 P.S.I.
3 P.S.I.
2 P.S.I.
1 P.S.I.
RADIUS OF ENVELOPE TO 100% L.E.L. GAS MIXTURE, INCHES
SPACE IN COMPARTMENT, CU. FT./ GUN

FIG. 13. Relation between the radius of an assumed envelope containing a gas mixture richer than the lower explosive limit and the differential pressure developed by burning the gas in a compartment of specified volume.

mixed quickly and thoroughly with the combustible gas at its source to prevent the formation of large volumes of combustible mixture.

### Additional Factors To Be Considered

In developing an adequate ventilation system that also conforms to good engineering design, there are a number of other factors that must be given careful consideration. Since guns are mechanical equipment, they are subject to malfunction if they become iced. Other equipment located in the same compartment may also be vulnerable to ice. Constantly open ventilation ports are, therefore, undesirable because they admit air in sufficient quantity to accelerate the chilling of the guns and other equipment. If, after the equipment has been chilled, the aircraft should fly through relatively warm air and then through a cold atmosphere, the well-known cold-sweat-cold cycle will take place. Furthermore, supercooled vapor zones that constitute icing hazards for wings and jet engines can also produce ice deposits in ventilated compartments. It is highly desirable, therefore, that these effects be minimized, by keeping the compartment as airtight as practicable when ventilation is not required. This can be accomplished with ventilation-actuating mechanisms operating only when the guns are fired. The actuators may be electromechanical, pneumatic, or hydraulic.

The pressure differentials existing in and about the aircraft may be employed to aid in controlling the desired flow of ventilating air. Ram air may be utilized in a similar manner. However, it should not be overlooked that negative pressures within the gun compartment may greatly accelerate the flow of muzzle gases into the compartment through openings in the vicinity of the gun muzzles. It has been estimated that a well-designed ram-air scoop 10 sq in. in cross-sectional area will provide sufficient ventilation for an installation of four 20-mm., M3, guns if flow channels within the aircraft are designed to offer minimum restriction and if adequate exhaust openings or louvers are provided in negative pressure zones. Other guns may require increased scoop area. The introduction of muzzle gas will be minimized if the intake is located well out of the air stream flowing back from the gun muzzles. Scoops may be located in the side of the fuselage away from the gun muzzles, and advantage may be taken of intervening structure, wings, or jet-engine ducts. When guns are located well aft on the sides of the fuselage, a forward intake may be used.

A study of the airflow and pressure patterns for aircraft in the design stage or in the model wind-tunnel test stage will be highly useful in selecting scoop locations. For aircraft already in service, camera records of the gun-smoke pattern will be of assistance.

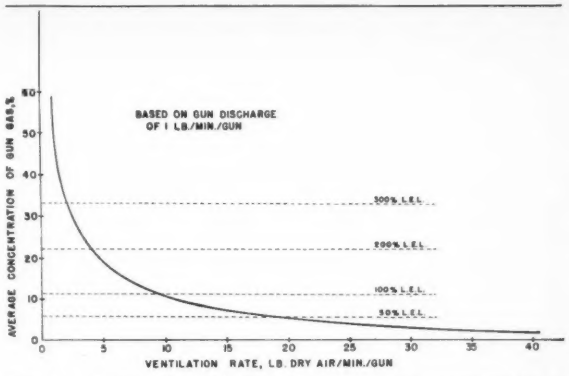

BASED ON GUN DISCHARGE OF 1 LB./MIN./GUN
AVERAGE CONCENTRATION OF GUN GAS, %
100% L.E.L.
200% L.E.L.
300% L.E.L.
VENTILATION RATE, LB. DRY AIR/MIN./GUN

FIG. 14. Effect of ventilation rate on average concentration of gun gas.

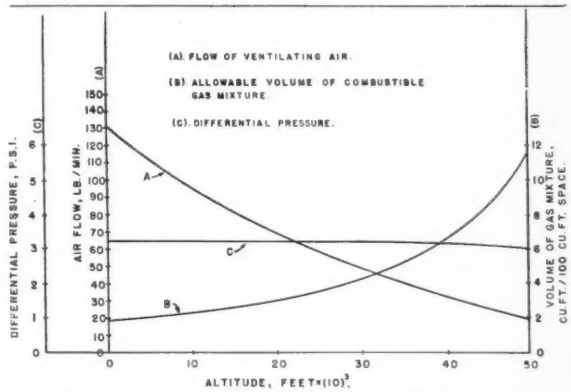

(A). FLOW OF VENTILATING AIR.
(B) ALLOWABLE VOLUME OF COMBUSTIBLE GAS MIXTURE.
(C). DIFFERENTIAL PRESSURE.
DIFFERENTIAL PRESSURE, P.S.I.
AIR FLOW, LB./MIN.
VOLUME OF GAS MIXTURE, CU.FT./100 CU.FT. SPACE.
ALTITUDE, FEET×(10)³

FIG. 15. Combined effects of altitude on differential pressure due to explosion.

Experience with early ventilating systems has indicated that they have usually been inadequate and that much energy and time is lost in cut-and-try efforts to bring installations up to mere marginal quality. Such marginal installations require careful and repeated testing under all conditions of flight to prove that they are safe. With this in mind, it would be well, in planning future installations, to be generous in the capacity of the ventilating system since, if it is later found that too much ventilation has been provided, a reduction in the size of intakes or ducts is easily accomplished.

Thus, if the greatest practicable amount of ventilation with clean air is provided in the initial design, the establishment through flight tests of operational acceptability will be expedited.

# Titanium

WILLIAM S. COCKRELL*
*Ryan Aeronautical Company*

TITANIUM—most modern metal of industry—is nature's paradox. More than any other element, this metal seems to exhibit exasperatingly contradictory behavior. Neither new nor rare, it costs the fabulous price of $15 per pound. With an extremely high melting point for its weight—higher than steel—it still will not withstand continued use at high temperatures. So "affectionate" for other elements that it is never found free, and although it instantly combines with other substances when molten, it will not weld with any other metals by known processes.

In spite of this "Dr. Jekyll and Mr. Hyde" complex, titanium is endowed with some of nature's choice characteristics that seem to be especially planned for aircraft applications. For this reason, the Ryan Development Laboratories have recently completed studies of the bright newcomer which involve the forming of intricate structures by established procedures developed for stainless steel.

Received November 8, 1951.
* Director, Development Laboratory.

Because titanium falls between the aluminum and steel alloys in both strength and resistance to temperature, it is the answer to many of the aircraft designer's problems. For years, engineers have been forced to specify heavier steel alloys in the design of structures that required more strength than aluminum alloys could provide at elevated temperatures. Because the aluminum alloys lose strength rapidly at temperatures above 300°F., this meant that a wide variety of components, such as fire walls, ducts, and shrouds, had to be built of stainless steel.

Titanium retains its exceptional strength up to temperatures of approximately 800°F. It weighs only 56 per cent as much as steel and approaches the best steels in strength. Some titanium alloys can now provide 175,000 lbs. per sq.in. tensile strength, and new types with 200,000 lbs. per sq.in. are being developed. With a lower linear coefficient of expansion and thermal conductivity than either aluminum or steel alloys, titanium is the only metal known to have an endurance strength consistently in excess of 50 per cent of its tensile strength.

In research at Ryan, flat sheet was formed to complex shapes to shroud the high-temperature exhaust system that Ryan builds for the Piasecki HUP-1 helicopter. This part operates at a temperature of 400° to 500°F. and appears to be an ideal application that combines the weight-saving and heat-resisting qualities of the metal. Also, it involves severe forming and resistance welding.

One of the basic aims of the investigation was to determine the adaptability of the machines and procedures used in forming stainless steel components to the forming of titanium parts. Obviously, economic advantages could be gained if conversion from stainless steel to titanium fabrication could be made without extensive re-tooling.

Little information is available on the production forming of titanium because it made its commercial debut in 1946 and only 60 tons of the metal were refined in 1950. The Ryan Laboratory established an experimental production procedure to determine the behavior of titanium when welded, formed, and heat-treated. To check the effectiveness of cold forming plus annealing and hot working of titanium, a number of sheets of 0.018- and 0.037-in. metal was used.

A spherical cavity was machined into a steel plate. The diameter of the cavity was $^{3}/_{4}$ in. and the depth $^{7}/_{32}$ in. By measuring the total deformation possible after forcing the titanium into the cavity with a steel ball using an impact load, it was possible to obtain quantitative evaluation of various annealing and pre-heat treatments. The results are shown in Table 1.

These tests indicated that either alternate cold forming and annealing or hot forming would be feasible. If cold forming and annealing are used, the point at which the part should be removed from the die is critical. The photograph on page 46 shows a cracked port section, partially formed in this manner.

In hot-forming procedure, the part was placed in one end of the body half-stamping die, heated to medium red heat, and deformed almost to completion. The part was then reheated and deformation completed. No springback occurred. A noticeable amount of lead adhered tightly to the surface that was struck by the lead punch. The part was successfully formed by drawing, heating, and hand-working in successive operations. The initial draw was fairly deep and entirely satisfactory.

An attempt was made to cold form two supports from the 0.037-in. material. The metal was placed in

TABLE 1

| Deforming Temperature | Treatment | Deforming Characteristics |
|---|---|---|
| Room | None | Cracked when deformation was about 50 per cent complete |
| Room | Deformed 50 per cent of possible, annealed 1 hour at 1,170°F. Deformation then completed | No cracking |
| Room | Deformed 50 per cent of possible, annealed 40 min. at 1,170°F. | No cracking |
| Room | Deformed 50 per cent of possible, annealed 20 min. at 1,170°F. Deformation then completed | Cracking appeared imminent |
| 450°F. | Previously heated to 1,300°F. | Cracked when deformation was nearly complete |
| 750°F. | None | Cracked when deformation was about 75 per cent complete |
| 1,000°F. | None | No cracking |
| 1,300°F. | None | No cracking |

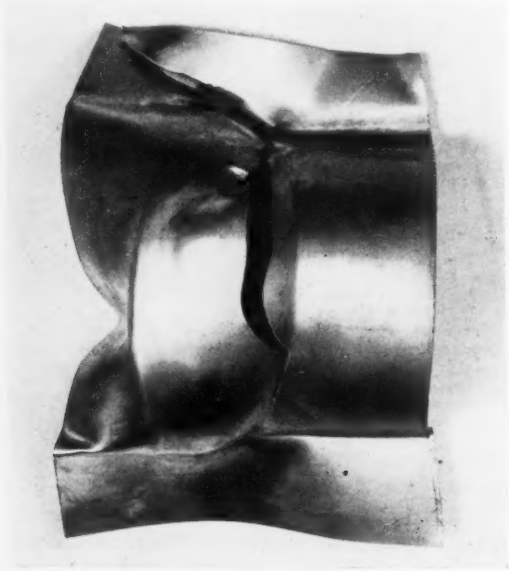
Closer tolerances are required for titanium parts than for stainless steel because excessive "springiness" makes mating more difficult. Ryan engineers check dimensions of Piasecki shroud section fabricated from titanium.

Experimental assembly of shrouded Piasecki exhaust system made up of stainless steel and titanium components.

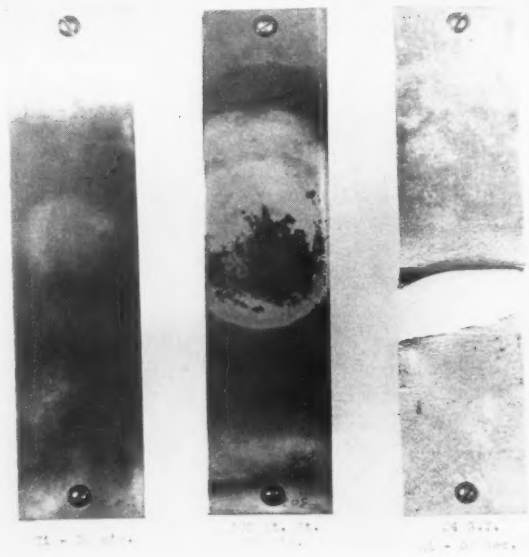
the die and hit several times. Forming was satisfactory except for a springback of about 1/8 in. measured at the ends. Annealing did not alleviate this condition. The thickness loss was found to be from 0.002 in. to 0.003 in. at the points of maximum deformation.

The scale on the hot-formed parts was removed by placing them for 5 min. in a salt bath descaling tank. The bath consisted of a mixture of sodium hydroxide and sodium nitrate at 850°F. After rinsing, they were dipped for 30 sec. in a cold pickle solution of 46 per cent nitric acid and 8 per cent hydrofluoric acid to remove the titanium dioxide that formed in the salt bath.

Close-up view of part of the Ryan-designed exhaust system shroud section for the Piasecki HUP-1 engine installation. Note the complex, deep-drawn contours and spot welding.



Cracked titanium shroud forming that was formed by a procedure involving cold forming and annealing. Crack was caused by difficulties in determining cold-forming limits of the metal in the die. For this reason, hot forming is more desirable.



Dramatic evidence of titanium's heat resistance, for limited intervals, is this Rem-Cru titanium photo of three test strips of titanium, type 302 stainless steel, and Alclad, 24ST aluminum alloy. All were exposed to 2,000°F. flames. The Alclad disintegrated in 30 sec. The titanium strip showed less effect than the stainless steel after 30 min. of this firey blast.

In spot welding titanium to itself, good spot weld results were obtained with machine settings that produced penetrations from between 70 and 90 per cent. Shear values were approximately 650 lbs. for the 0.018-in. commercially pure titanium and 1,300 lbs. for 0.037-in. combinations. No success was experienced in spot welding titanium to other metals.

From these experimental investigations, Ryan development engineers are convinced that most stainless steel forming techniques can be adapted to the fabrication of titanium parts, similar to the Piasecki shroud. The metal should be deformed at temperatures between 800° and 1,000°F., preferably closer to the maximum temperature. Although lead dies are not practical because of the lead pick-up, steel or cast iron dies should prove satisfactory. Heated dies would be desirable and economic for large-run production. Use of a controlled atmosphere furnace would prevent the formation of most scale due to heating.

Although discovered back in 1791 by an English clergyman named Gregor, titanium was not produced commercially until 1946 when William Kroll, a U.S. Bureau of Mines engineer, evolved a process for separating it from its ore. A clue to the tremendous affinity that titanium has for other substances can be gleaned from the fact that the ore can be purchased in the market at only two cents a pound but the refined metal costs from $10 to $20 per pound. Major sources of the metal, which is still produced on a limited basis, are

(*Continued on page 54*)

# Some Practical Experience with Civil Jet Transport Operation and Associated Meteorological Problems

A. C. CAMPBELL ORDE*

*British Overseas Airways Corporation*

## (I) Introduction†

During the early part of this year, British Overseas Airways Corporation will introduce on the London to South Africa route the first public passenger service with jet transport aircraft in the history of the air-line business. Meanwhile, preparations are being completed, including training of air and ground personnel, procurement and provisioning of parts, and specialized equipment for our home base at London Airport and stations along the route. The important initial operational development flying program has already been done. From March, 1951, to the end of that year, 631 hours of practical flying experience have been built up by B.O.A.C., using one of the two Comet I prototypes and later a production model. This included overseas flights to South Africa, India, and Malaya. Preliminary operating experience of the greatest value has been obtained in this way, with the object not only of checking performance methods, but of investigating actual conditions and facilities along the routes at double the operating speeds and altitudes to which we have been accustomed in the past. The success achieved has been due to the enthusiastic collaboration among manufacturers, operators, and the Ministries of Civil Aviation and Supply in the United Kingdom, and also the authorities concerned in territories along the routes, without whose wholehearted support these things could not have been done in so short a time.

The flights have happily confirmed much of our early thinking and calculations. In March, 1951, the Comet I had already reached an advanced state of development, thanks to the thorough and extensive flight-test program of the de Havilland Aircraft Company, Limited. The real value of the route flying subsequently done by B.O.A.C. has been in the operational field, throughout which all current conditions have had to be put into new perspective. Increasing operating speeds and altitude at one step by so large an amount has highlighted existing deficiencies in operating facilities. However, the change has been one of emphasis, rather than fundamental.

The effect of the time reduction is felt throughout the whole operation; both air and ground personnel have to be continuously alert and work faster, take decisions quicker; information from the ground must be prompt and available at the correct points throughout the flight to enable these decisions to be made. Doubling cruising speed has accentuated organization and communications problems; doubling the operating altitude introduces a new region of air-line meteorology.

The Comet I is the forerunner of the air liner of the future. It has already demonstrated the rightness of this conception. It is not the purpose of this paper to enlarge upon the subject of the aircraft itself, though it is necessary to stress that we are no longer considering a specialized kind of aircraft of narrow practical application but one which, because of its essential advantages now so well demonstrated, will soon become a familiar everyday affair once the traveling public has tasted the overwhelming improvement in service offered. Everyone who has traveled in the Comet is unanimous about this.

It is proposed to concentrate upon the meteorological aspects of this type of operation from the experience so far gained, inviting attention to the important influence of meteorological factors upon the overall economy of operation, first, in the project stage, second, in operating methods, and last, to refer to the meteorological services required by air lines for jet operation on international trunk routes, since it is felt that it will be upon these that the effect of accelerated services will be greatest.

Having examined these considerations, it is proposed by way of a practical illustration to give a running commentary of a recent development flight by B.O.A.C. with a Comet I prototype in current conditions from London to Singapore and return. Instances will be seen where these problems were exemplified, and their effect upon the flight can be noted. By way of conclusion, some suggestions for the future will be made.

## (II) Influence of Meteorological Factors upon the Overall Economy of Operation of Jet Aircraft

### (*a*) *Basic Importance of Meteorological Conditions to Jet Operation*

The criteria required for laying down the design of a new civil jet project or for evaluating its scheduled operation are still of necessity less definite or complete than those so well established for current types of aircraft. At present, meteorological statistics about local airport conditions and about routes in many parts of the world are inadequate, and data are not yet presented in the most suitable form to show probable incidence of occurrence of maxima and minima.

Presented at the Meteorology Session, Twentieth Annual Meeting, I.A.S., New York, January 28–31, February 1, 1952.

* Operations Development Director.

† All distances are in nautical miles; speed in knots.

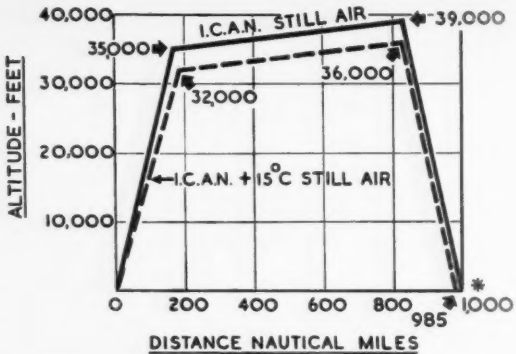



FIG. 1. The effect of temperature rise on range.

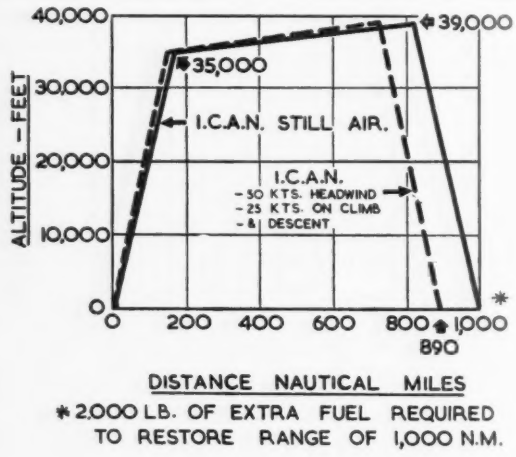



FIG. 2. The effect of head wind on range.

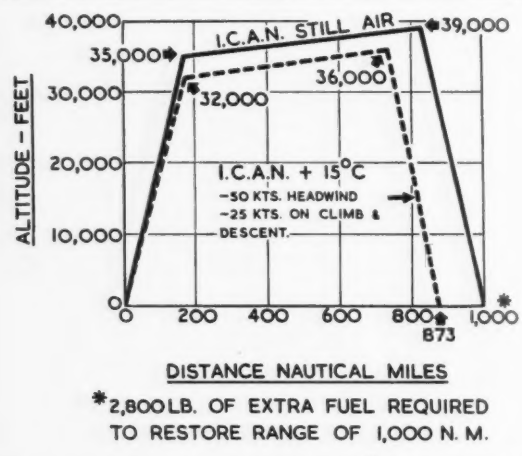



FIG. 3. The combined effect of temperature rise and head wind on range.

In general, the take-off performance of a jet aircraft is most sensitive to temperature, but its range is most sensitive to wind. With the Comet a difference of 1°C. at take-off is equivalent to from 250–400 lbs. pay load at airports between sea level and 5,000 ft. In considering the range of such an aircraft, the relative importance of both wind and temperature must be appreciated. Figs. 1 to 3 illustrate by how much the take-off weight would have to be increased to restore the loss of range suffered in higher temperatures or against head winds. The effect of these in turn upon the direct operating cost is given below in Tables 1 and 2.

The basis taken is a sector on which volumetric pay load can be carried without meeting either runway or gross weight restriction, within the maximum range associated with this pay load. The increases of direct operating cost (pence per capacity ton mile) arise only from the extra fuel required to meet the conditions stated—namely,

I.C.A.N. + 15° and still air = 200 lbs. of extra fuel
I.C.A.N. and −50 knots = 2,000 lbs. of extra fuel
I.C.A.N. + 15° and −50 knots = 2,800 lbs. of extra fuel

Table 2 compares similar examples, but it has been assumed that take-off weight is the same throughout and cannot be increased, for example, because of inadequate runway length. Here the extra fuel required can only be carried at an equivalent reduction of pay load.

Furthermore, in the interests of overall economy, jet aircraft should always be flown at the lowest possible gross weight for a given job. The carriage of any unnecessary fuel has a disproportionately large adverse effect upon the result, even though the gross weight may be available to permit it. This penalty is proportionately greater for a jet aircraft than it would be for piston propeller types, where some additional increase of weight of fuel reserves can be tolerated.

### (*b*) *Economic Aspects of Operating Procedures*

The methods of diversion to alternates and their effect on fuel reserves are compared in Fig. 4. It should be noted that with such an aircraft the total

TABLE 1
Take-Off Weight Not Limited

| | I.C.A.N. and Still Air | I.C.A.N. + 15° and Still Air | I.C.A.N. and −50 Knots | I.C.A.N. + 15° and −50 Knots |
|---|---|---|---|---|
| Block-to-block speed, knots | 359 | 355 | 323 | 316 |
| Sector time, hours:min. | 2:47 | 2:49 | 3:06 | 3:10 |
| Net per cent increase in direct operating cost | ... | +1.2 | +10.5 | +11.65 |

Sector distance, 1,000 nautical miles; volumetric pay load, 11,500 lbs.

TABLE 2
Take-Off Weight Limited

| | I.C.A.N. and Still Air | I.C.A.N. +15° and Still Air | I.C.A.N. and −50 Knots | I.C.A.N. + 15° and −50 Knots |
|---|---|---|---|---|
| Net per cent increase in direct operating cost | ... | +2.98 | +33.8 | +47.7 |

Sector distance, 1,000 nautical miles.

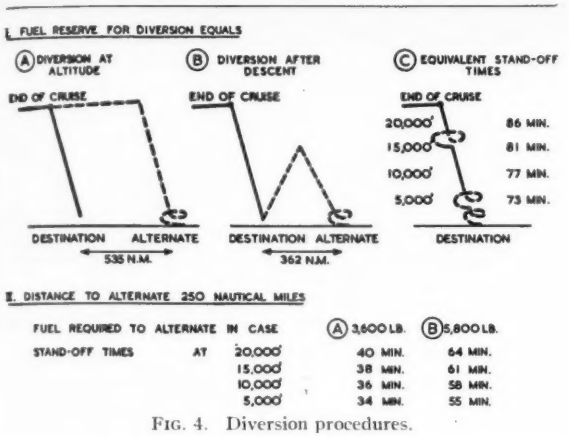



FIG. 4. Diversion procedures.

weight of fuel reserves is roughly equal to volumetric pay load.

The first part of this diagram shows the different distances that can be flown with the same fuel reserve if diversion is made A, at cruising altitude, and B, after descent to destination; C shows the equivalent stand-off times.

The second part of the diagram shows, using the same operating procedures A and B, the amount of fuel required for diversion to an alternate 250 miles away. The corresponding stand-off times are also given at four different altitudes.

To sum up—whereas roughly volumetric pay load can be carried over this range, there would be a loss of 24 per cent in pay load if diversion is made after descent to destination. Comparing this with typical current equipment, such as the Constellation 749 at 102,000 lbs. gross weight, we find that the Constellation requires little difference in fuel for either procedure, the loss of pay load amounting to only 2.5 per cent for diversion after descent.

## (III) Effect of Increased Operating Speeds of Jet Aircraft upon Meteorological Services Required

### (a) *Importance of Meteorological Organization in Actual Operation in Relation to Large Reductions in Flight Time*

Fig. 5 describes a typical flight over an intermediate sector of a long haul route, showing the operating procedures suggested and the intervals at which meteorological information will be required by the pilot. The diagram shows the characteristics of a civil jet operation of this kind, and the legend gives in detail the suggested sequence of events and the significance of meteorological services at each point.

Compared with current types of aircraft, the need for a "Howgozit" system for progressing the flight is obviously greater, and it will be important for the pilot to keep this up to date through the whole operation so that he will be aware at any moment of any deviations from flight plan and of fuel remaining. If we consider the longest haul, it will be readily seen that within the next few years we shall have a civil jet air-

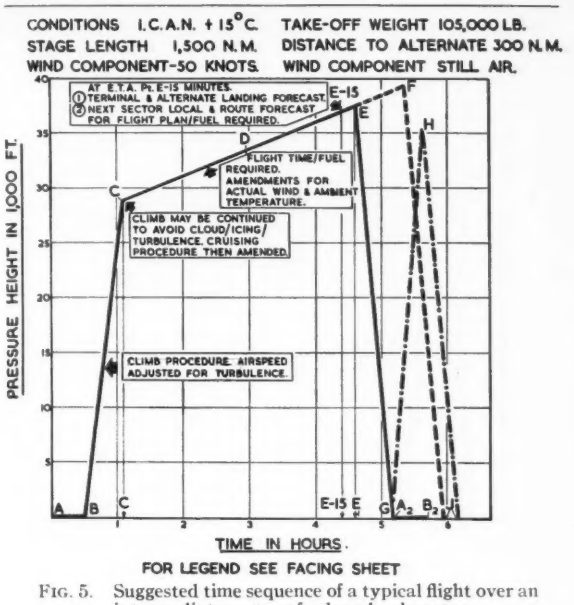

CONDITIONS I.C.A.N. + 15°C. TAKE-OFF WEIGHT 105,000 LB.
STAGE LENGTH 1,500 N.M. DISTANCE TO ALTERNATE 300 N.M.
WIND COMPONENT-50 KNOTS. WIND COMPONENT STILL AIR.
AT E.T.A. Pt. E-15 MINUTES.
① TERMINAL & ALTERNATE LANDING FORECAST.
② NEXT SECTOR LOCAL & ROUTE FORECAST. FOR FLIGHT PLAN/FUEL REQUIRED.
FLIGHT TIME/FUEL REQUIRED. AMENDMENTS FOR ACTUAL WIND & AMBIENT TEMPERATURE.
CLIMB MAY BE CONTINUED TO AVOID CLOUD/ICING/ TURBULENCE. CRUISING PROCEDURE THEN AMENDED.
CLIMB PROCEDURE. AIRSPEED ADJUSTED FOR TURBULENCE.
PRESSURE HEIGHT IN 1,000 FT.
TIME IN HOURS.
FOR LEGEND SEE FACING SHEET

FIG. 5. Suggested time sequence of a typical flight over an intermediate sector of a long haul route.

### LEGEND FOR FIG. 5

***Flight Procedures***

- A = landing, previous sector
- B = take-off
- A–B = Desirable ground time for (1) final flight plan and (2) fuel uplift
- B–C = initial climb to cruising height dependent upon (1) cruising procedure to be followed, (2) aircraft weight, and (3) ambient temperature
- C = start of cruising climb
- C–E = cruising climb. Gradient influenced by (1) cruising procedure, (2) wind gradient, and (3) temperature gradient
- D = point of *no return*/engine failure (symbolic)
- E = end of cruise climb—start of descent
- $A_2$ = landing
- $B_2$ = departure take-off
- E–F = cruise for diversion at height
- F = start of descent to alternate
- G = low altitude wave-off
- GHJ = climb and descent of low altitude diversionary procedure to alternate J

***Meteorological Information Required***

- A = amendments to route—departure forecast. (1) ambient temperature, wind velocity for use at B; (2) route wind velocities, temperature gradients; and (3) cloud icing conditions, upper air turbulence
- B–C = route forecast amendments (2) and (3) above
- D = forecast corrections wind, temperature. (1) 30,000–40,000 ft. four-engined return; (2) 20,000–30,000 ft. three-engined flight, whole sector
- E–15 = forecast for next sector AND; terminal weather $A_2$
- E = committal to land at $A_2$, unless penalty of extra fuel for low altitude diversion accepted
- $A_2$ = landing with flight plan and fuel required for next sector subject amendment for (1) change in take-off wind velocity/ambient temperature forecast, (2) changes in route forecast, and (3) next terminal/-alternate local forecast

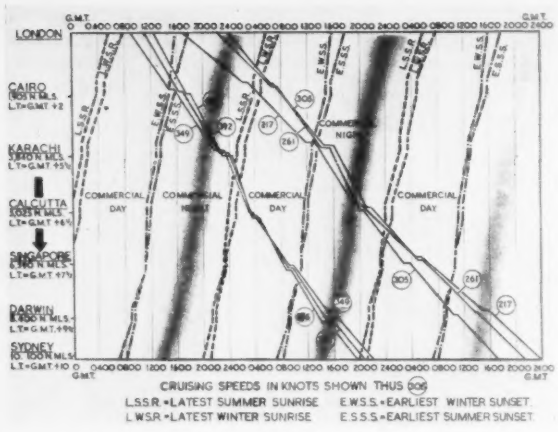



FIG. 6. United Kingdom–Australia in 6 stages.

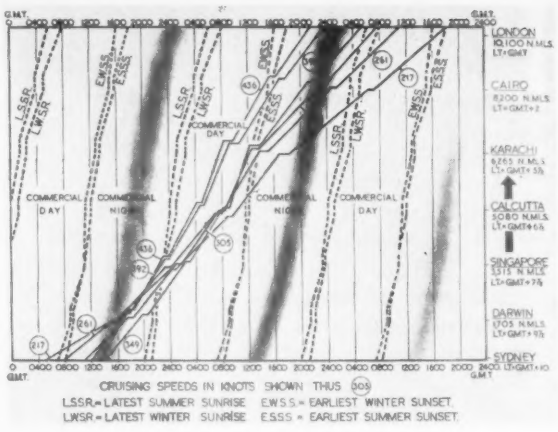



FIG. 7. Australia–United Kingdom in 6 stages.

craft capable of operating routes such as London to Sydney—namely, half way around the world—within about 24 hours (that is, within the normal 24-hour forecast period). We can therefore visualize the pilot making a complete flight plan for the whole route before the start, covering each sector, and amending this as he proceeds on his journey. If meteorological services and communications facilities are developed to make this possible, the elapsed time for the whole journey can be reduced to the absolute minimum, transit stops will be as short as possible, and maximum revenue loads can be made available to the selling organization of the air line.

It will already have been seen how vital it is to the pilot to be given up-to-the-minute weather information for landing conditions at his destination, or the designated alternates, when he reaches point E or a few minutes before this point, so that he can make the correct decision promptly. Point E represents the crux of a typical jet flight.

The position of the aircraft relative to point E must be fixed as accurately as possible; thereafter navigation is virtually over and the pilot will want the means to know "which way to go next," including precise information as to his distance away, so that his ETA's are closely adhered to as he enters the air-traffic pattern within the control zones at his destination.

### (*b*) *Reduction of Elapsed Journey Times on Trunk Routes United Kingdom–Sydney, United Kingdom–New York*

Figs. 6 to 9 show what will be involved on some of the long trunk routes and are intended to serve as good examples for illustrating the meteorological organization and services needed to achieve these objectives.

### (*c*) *Daylight and Darkness Problems*

Attention must be drawn to the daylight/darkness sequences on east/west routes. It will be seen from the charts that at 436 knots it is possible to operate from Singapore to London in daylight the whole way. Fig. 10 illustrates the same problem on the North Atlantic, and, in this case, which is even more dramatic, the aircraft will approximately keep position with the sun at this speed, flying westbound along the 60th parallel.

For the passenger, it will no longer be appropriate to discuss a journey in terms of days and nights; this will be a matter of hours only.

## (IV) London—Singapore and Return by Comet

The following running commentary by our Meteorological Officer on a recent development flight by B.O.A.C. with their Comet in current operating conditions may help to illustrate the inadequacy of existing high-altitude meteorological services and of associated communications. In-flight weather information was generally found too slow; also, the time taken to clear meteorological reports by HF/RT channels was excessive. It will not be practicable to make pomar reports by RT, and some other means of getting the benefit of actual weather information obtained by aircraft operating at high speed and high altitude will have to be devised.

### (*1*) *London—Cairo*

"On course 100817 GMT, arrived (overhead) 1322. A head wind was encountered as far as Rome, although a tail wind was forecast, and at 1130 the air speed was increased to make up lost time. In the Central Mediterranean the winds were southwesterly (beam) as against a forecast of strong westerlies while dense cirrus at 35,000 ft. appeared in the usual place from the toe of Italy to Crete. Very light turbulence was experienced in cirrus SE of Crete at 39,000 ft. No cloud was forecast above 30,000 ft.

"Three pomar reports were sent by W/T to London at 1140 GMT. From 1200 GMT onwards, forecasts and actuals were received from Cairo on R/T. At 1212 GMT a pomar was sent to Cairo on R/T

### (*2*) *Cairo—Karachi*

"On course 101430 GMT, arrived 1932. Winds were not as favorable as forecast, and the arrival was

14 min. late on flight plan. Temperatures were forecast accurately—I.C.A.N. + 14 for the climb and I.C.A.N. + 7 for the cruise. Slight turbulence was experienced in cirrus at 38,000 ft. at 1730 GMT at 54°E, otherwise there was no cloud as forecast. A pomar was sent to Cairo by R/T at 1540 GMT. At 1608 GMT, considerably behind on flight plan, a Karachi terminal forecast was requested from Basra. At 1615, Basra requested this forecast from Delhi on R/T, and the forecast was passed to the aircraft by Basra at 1657 GMT. At 1710, the Karachi actual was sent by Delhi, and at 1810 one was sent direct from Karachi.

(*3*) ***Karachi—Bangkok***

"On course 102155 GMT, arrived 110350 GMT. During briefing, the forecaster at Karachi stated that there would be no cloud above 20,000 ft. apart from broken cirrus at 25,000 ft. associated with a depression in the Bay of Bengal. He stated also that the westerlies at cruising height would extend to 18°N, and that, although Bangkok had forecast easterlies, we should probably have westerlies along the whole route. Easterly winds were encountered half way across India, and, from the coast onwards, there were strong southeasterly winds. Considerable cloud at 40,000 ft. appeared over eastern India, and slight turbulence was experienced south of Calcutta where the aircraft was just above some cumulonimbus. The Peravia accelerometer was switched on, but the turbulence ceased. Cloud photographs were taken over the Bay of Bengal whenever possible, but, although the aircraft was cruising at 41,000 ft., it was often in or near cloud. Cumulonimbus tops to about 45,000 ft. were seen to starboard. Over Burma, only small cumulus was seen and appeared as tiny specks of cotton wool. Cirrus at about 40,000 ft. was seen about half way between Rangoon and Bangkok. Terminal forecasts for Calcutta and Rangoon gave visibility occasionally 1 mile, and, for Bangkok and Saigon, occasionally 2 miles, and, at 2249 GMT, Delhi was asked to supply the latest landing forecast (QFZ) for Bangkok. At 0003 GMT, Delhi asked Calcutta if the landing forecast was available. At 0031 the aircraft asked Calcutta for the landing forecast and at 0052 Calcutta passed the message to the aircraft. At 0127 Bangkok sent the latest actual to the aircraft; at 0207 an actual and landing forecast were sent followed by further actuals at 0236 and 0307 (0200 and 0230 reports, respectively).

(*4*) ***Bangkok—Singapore***

"On course 110627 GMT, arrived 0844. Winds were light and agreed with the forecast. Temperatures were accurate to 30,000 ft., but at 40,000 ft. a forecast of −65°C. was given for the latter part of the route while the aircraft observation was −53°C. Cumulus tops were forecast at 15,000 ft. with cirrus above extending from 20,000 ft. to 25,000 ft. On reaching the Malayan coast at 37,000 ft., light to moderate turbulence was experienced for a few seconds. At 0805 GMT at 40,000 ft., the aircraft was just on top of a layer of thick cirrus with a very large cumulonimbus to starboard resembling an atomic explosion. Two minutes later the aircraft was in cloud. During the descent through cirrus, there was no turbulence, and the aircraft broke cloud at 0840 GMT at 20,000 ft. There were small amounts of cumulus and strato-cumulus below.

"Singapore supplied a forecast for the second half of the route at 0720 GMT, but the radio operator was occupied for 20 min. in taking the message.

(*5*) ***Singapore—Bangkok***

"On course 160159 GMT, arrived 0412 GMT. Largely as the outcome of debriefing from the incoming flight, the forecast issued by Kallang included isolated cumulonimbus on the coast to 30,000 ft. with dense cirrus extending to 40,000 ft. around Kota Bharu. Cumulonimbus was seen shortly after becoming air borne but appeared to be dissipating rapidly. Photographs were taken as the clouds showed a pronounced shearing effect. At 0246 GMT at 34,000 ft., the aircraft was in cloud and slight turbulence experienced one minute later. At 0300 GMT around Kota Bharu, the aircraft at 36,000 ft. was below cirrus. At 0312

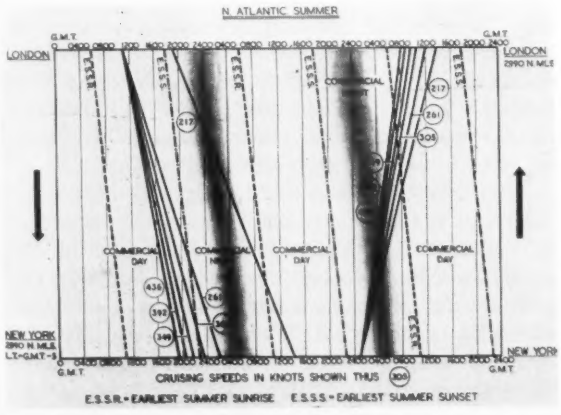



FIG. 8. United Kingdom–New York–United Kingdom in one stage at 40,000 ft.

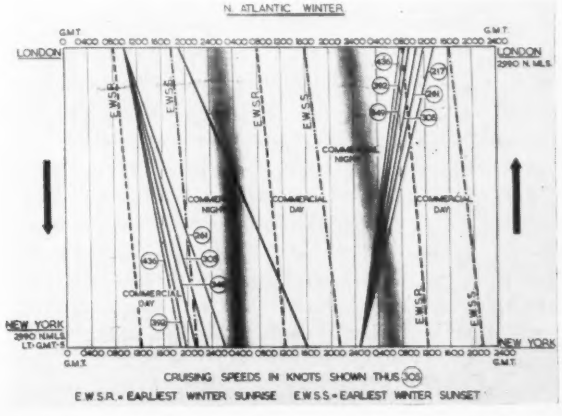



FIG. 9. United Kingdom–New York–United Kingdom in one stage at 40,000 ft.

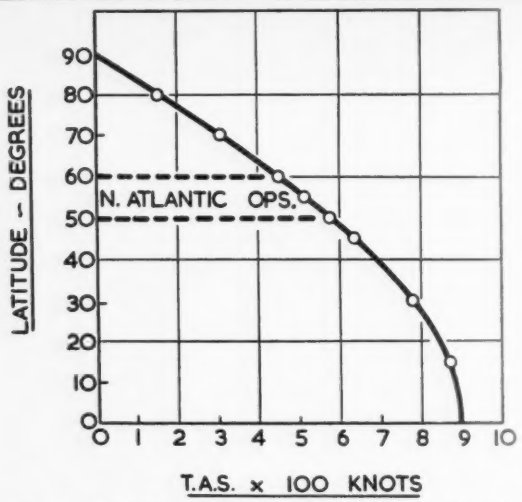



FIG. 10. Latitude vs. aircraft speed at which the aircraft flying westward on a parallel of latitude keeps pace with the sun.

over the sea, slight turbulence was experienced in cirrus but the cloud broke quickly to small amounts. At 0339 also at 36,000 ft., cumulonimbus was seen to starboard again with a pronounced shear effect. Descent was commenced at 0346, and at 0400 at 23,000 ft. the aircraft altered course to avoid cumulonimbus. Light to moderate turbulence was experienced while continuing the descent through large cumulus and cumulonimbus.

"At 0300 GMT, Bangkok sent winds and landing forecast (QAO/QFZ) to the aircraft by R/T.

### (6) *Bangkok—Calcutta*

"On course 160161 GMT, arrived 0905. Just before take-off there was a heavy thunder shower, and visibility was reduced to $1^1/_2$ miles. Winds were not seriously in error, though temperature on the cruise was forecast 5°C. too hot and there was much more cloud than forecast. There was well developed cumulonimbus along the whole route, and photographs were taken whenever practicable. A severe thunderstorm warning was received from Rangoon at 0700 GMT. At 0715 GMT at 36,000 ft., light turbulence was experienced in cirrus and at 0718 GMT there was a light to moderate 'bump.' At 0730 GMT the aircraft was in cloud again at 38,000 ft., and there was light turbulence. At 0737 the cirrus lifted and cumulonimbus was abundant. Cloud was entered again at 0745 at 38,000 ft., but at 0754 until the descent there was a sheet of cirrostratus well above the aircraft, which was cruising at 40,000 ft. At 0834 the descent was commenced and course altered to avoid cumulonimbus. Turbulence was hardly perceptible while descending through layer cloud, base 20,000 ft. Below 20,000 ft. it was possible to avoid most of the cloud and a smooth descent resulted. At 0750 GMT, Calcutta sent a landing forecast to the aircraft.

### (7) *Calcutta—Gaya and Return*

"On course 170147 GMT, arrived 0234. Return 0425 GMT, arrived 0508. There was no cloud over the route, but cumulonimbus was seen over the mountains to the NW. Towards Calcutta on the return, the cumulus was seen to be building rapidly, and on landing there was some well developed large cumulus Mount Everest was plainly visible.

### (8) *Calcutta—Karachi*

"On course 170733 GMT, arrived 1127. Meteorological briefing was given by the Senior Meteorological Officer, Dum Dum, and the Regional Director, Calcutta, was also present. Although charts were prepared at 300 mb. and 200 mb., based on 0200 GMT winds for 9 stations between 20 and 30°N in India, six of which extended to 200 mb., the westerlies were stronger than forecast, and the aircraft was 10 min. late on flight plan. Temperatures were forecast accurately for the cruise—I.C.A.N. + 10. Cloud forecasts again were poor. Cumulus tops were forecast to 15,000 ft. from Calcutta to 75°E, whereas a number of cumulonimbus extending to 36,000 ft. and above were seen on either side of track. Some of these clouds showed a large increase in the westerlies above 30,000 ft. and resembled smoke coming from a long funnel. The cloud forecast west of 75°E gave isolated thunderstorms and cumulonimbus to 40,000 ft.; whereas the tops extended to about 20,000 to 25,000 ft. and no cumulonimbus was observed during the last 45 min. of the flight. Descent was made through a thin sheet of altostratus. Above, and also in, this cloud the ground was plainly visible. Photographs were taken of the cumulonimbus on the port side along the whole route. At 0856 GMT, Karachi was asked for landing forecast Karachi, and this was received from Delhi at 0942. At 0905 GMT, a pomar was sent to Delhi and Calcutta; at 0945 GMT, one was sent to Delhi, and, at 1030 GMT, the pomar report was sent to Karachi and Delhi.

### (9) *Karachi—Basra*

"On course 180319 GMT, arrived 0641. Although a vague warning was issued at 171830 GMT concerning fog and stratus in the Karachi area until 180200 GMT, no mention of fog affecting the airport was made at the briefing. Just before scheduled take-off (0130 GMT), visibility to the east was about 400 yards but over 1 mile to the west, and the airport authorities "closed" the aerodrome. In such conditions, with no wind, it seemed unnecessary to prevent the aircraft from taking-off. At 0200 GMT, the fog thickened slightly, and shortly afterwards visibility was reduced to 200 yards generally and lasted 1 hour. The Meteorological Office was unable to give the time of clearance and extended the fog warning to 0300 GMT and later, a few minutes before improvement, to 0330 GMT. Mauripur visibility remained above 1 mile throughout. The route forecast was reasonably accurate, but temperature on

the cruise was I.C.A.N. + 6 as against a forecast of I.C.A.N. + 15. The forecaster mentioned a frontal zone at about 55°E, which had not been included in the Rofot from Habbaniya. Cirrus was seen in this area at about 30,000 ft., and a thick band at about 35,000 ft. was noted to starboard over Persia. In order to make up for lost time and to reduce refueling stops to a minimum, it was decided to compute fuel figures for the next sector before landing, and Basra was asked to supply the winds (QAO) Basra—Cairo at 0352 GMT. The message was received at 0455 GMT and included landing forecast (QFZ) Basra. A Basra actual was received on R/T at 0540 GMT.

(*10*) ***Basra—Cairo***

"On course 180727 GMT, arrived 1023. The forecast wind direction was accurate, but speeds of 110 knots were encountered as against 60 knots forecast. Temperature over the cruise was I.C.A.N. + 6 as against I.C.A.N. + 12 forecast. There was no cloud apart from cirrus at 32,000 ft. over Sinai. At 0822 GMT, Cairo was asked to supply winds (QAO) Cairo—Rome by W/T. When the radio operator switched over to HF R/T, Cairo was heard sending the winds (QAO) to Damascus, and part of the message was copied direct. Damascus then relayed the message to the aircraft with five corruptions and omitting the temperatures. At 0906 GMT, Cairo retransmitted the complete message by W/T.

"At 0840 GMT, a pomar was sent to Basra on HF R/T.

(*11*) ***Cairo—Rome***

"On course 181144 GMT, arrived 1530. From Crete to the toe of Italy winds were forecast as 260/50 becoming 170/50, whereas the winds encountered were 260/120 knots. There was no backing of the wind during the cruise. The charts showed rawind reports from Nicosia, Benina, and Malta of the order of 70 to 80 knots, but, according to the navigation log, these speeds were doubled in places. Temperature forecasts were satisfactory. No cloud was forecast above 25,000 ft., but at 20°E, in the usual place, a sheet of cirrostratus appeared just below the aircraft at 38,000 ft. Ten minutes later, light to moderate turbulence was experienced in this cloud at 39,000 ft. At 1508, approximately 40½N 13½E, the base was reached at 27,500 ft. Thus the cirrus was about 10,000 ft. thick. Below this there was a good cover of altocumulus which merged with the cirrus well to starboard. Some cumulonimbus was seen to port and extended to the cirrus level.

"The terminal forecast for Rome gave occasional rain, and Malta gave a risk of stratus at 500 ft. With continued head winds above forecast, it was necessary to maintain a constant check on fuel figures and to decide on possible diversions in the light of fuel available. The captain of the aircraft therefore required the latest reports and forecasts for his terminal and alternates to be constantly available. However, communication with Malta was difficult, and up-to-date information on Malta weather was not available when required. In addition, landing forecast (QFZ) for Nice was not obtained until 1449 GMT, when Luqa passed the information on VHF.

(*12*) ***Rome—London***

"On course 191130 GMT, arrived 1400. Winds for the second half of the route supplied by London were 190/15 becoming 190/25, whereas the navigator found head winds. An examination of the charts for 191500 GMT shows that reported winds from radar and pibal ascents were 190° to the east of track, but no reports were received from stations on the track. The sequence of 200 mb. charts at London Airport from 0300 GMT on 18th October to 1500 GMT on 19th October shows a trough extending from United Kingdom to the western Mediterranean with a closed center within the trough. The movement of this center seemed to be erratic and rather obscure, and the head winds experienced were probably on the west side of the center. The temperature and cloud forecasts were accurate. Cloud was broken over the Alps and well below the level of the aircraft and had a uniform rippled top with humps following the topography of the ground. Photographs were taken. London Airport supplied forecasts and actuals throughout the flight on HF R/T channels."

It will be seen, for instance, how preliminary flight plans were prepared in flight for the next sector on certain occasions in order to save time; also the need, on the Cairo/Rome and Cairo/Karachi sectors, for prompter meteorological services approaching Italy and Karachi so as to decide whether or not to proceed to destination or alternate can be seen.

The eastbound flight from Karachi to Bangkok direct represented the longest so far flown by the Comet and was of particular interest, since it had to pass through the tail end of the monsoon season. Considerable cloud was found at cruising altitude, and over a distance of some 600 miles the aircraft was more or less continuously in cloud at around 40,000 ft. Turbulence, however, was only slight and no difficulty was experienced. Generally speaking, a great deal more high-altitude cloud has been encountered than has been forecast. Forecast and actual winds at high altitude have differed greatly, not only in strength but also in direction. This is shown in the history of the flight.

In Malaya, where severe thunderstorms are prevalent throughout the year, the use of search radar on the ground for locating and identifying them in the vicinity of the terminal is suggested. Only moderate turbulence was encountered at any point, although course was altered to avoid local cumulonimbus formations near Calcutta when letting down before arrival from Bangkok.

## (V) Conclusions and Suggestions

It has been possible to cover only part of this wide field of subjects, but it is hoped that enough has been

said to emphasize the increased importance of meteorology for the efficient and economic operation of civil jet aircraft at high altitudes and to stimulate thought for the future.

Nothing insuperable has emerged from the work done by British Overseas Airways Corporation with the Comet; this has now reached the normal operational stage. Such difficulties as have been met have proved no greater than those so successfully overcome in the past at lower altitudes and speeds in other types of aircraft. The following are particularly stressed.

(1) More intensive upper air research on a world-wide scale is urgently needed. Radiosonde and rawinsonde coverage is still far from adequate. Neither these nor pomar reports, which have been found impracticable for this purpose, are likely to provide a satisfactory source of information for day-to-day air-line use, and some new means may have to be developed.

(2) Wind forecasts at high altitudes have been found inaccurate; the effect of this upon range will be greatest on east/west routes. Temperature has relatively smaller effect upon range but more on take-off performance, for which more adequate and more suitably presented airport data are needed.

(3) A great deal more cloud has been found at high altitude than expected or forecast; no serious turbulence has yet been experienced. It is suggested that both air-borne and ground search radar equipment may be of value for avoiding turbulent cloud formations, particularly for identifying and locating these during climb or descent.

(4) Weather information services and associated communications will need to be correspondingly improved and synchronized with the accelerated services operated by jet aircraft and organized expressly for the purpose; reduced time means that both air and ground personnel must work faster and take decisions quicker.

(5) A more global type of weather service and organization is needed. The high-speed operation of long distance routes requires the linking up of various local organizations through which the routes pass so as to give the operator more comprehensive data on which to base flight plans from the outset. This should be feasible within a normal 24-hour forecast period.

Current weather information must be more readily available, including amendments to forecasts and actual weather reports before and during flight. The main staging posts along the route should arrange for the supply of this information to all associated nominated alternates, so that it may be sent to the aircraft immediately upon request.

(6) Communications, air and ground network, must be complete. Voice communication between air and ground becomes not only economically desirable but an operational necessity because of the time factor.

(7) Finally, closer international cooperation between the authorities or agencies concerned and the air-line operators offers the best way of solving these problems quickly.

## Titanium

(*Continued from page 46*)

Titanium Metals Corporation of America and Rem-Cru Titanium, Inc. Another company, Horizons, Inc., is hard at work on a new process for refining titanium which promises to reduce its present production costs by 80 per cent.

Greatest immediate use for titanium and its alloys will undoubtedly be in the formation of aircraft "skins," or surfaces, for supersonic planes. Friction induced heat is now zooming temperatures of these high-speed aircraft to well above aluminum alloy's limits. Titanium could handle these critical temperatures with ease and buoyancy.

The keenest disappointment that titanium has caused metallurgists, who looked with relish upon its 3,150°F. melting point and hexagonal crystalline structure, is its inadequacy to withstand continued temperatures above 1,000°F. For short periods, titanium behaves beautifully. At exposures to 2,000°F. flames, aluminum plates disintegrated in less than 1 min. and titanium showed no adverse effects after 30-min. exposure. Upon cooling to room temperature, it had regained its typical annealed strength.

However, under continual temperatures of more than 1,000°F., titanium suffers an irreversible absorption of oxygen and nitrogen, which rapidly reduces its ultimate and yield strengths and causes it to become brittle. If this deficiency could be overcome so that titanium would remain useful up to temperatures of 1,600°F., a whole new field of applications would be uncovered. Combustion chambers, inner and outer cones, tailpipes, and transition liners for jet engines would use large quantities of the metal.

Ryan development engineers and metallurgists are working on this avenue of research which falls into Ryan's extensive experience with high-temperature applications. Because titanium's deterioration at continued high temperatures appears to be due to events that occur at the surface of the metal, great hope is held for its future in these hot spots if something can be done to protect its surfaces against oxidation and absorption. Experiments with new ceramic coatings on titanium to determine the success of these materials that have been so beneficial in preventing the oxidation of stainless steels at extremely high temperatures are also being carried out. The outcome of these important evaluations may have a great influence upon the employment of titanium in these specialized fields.

# A Revolution in Technique

(*Continued from page 33*)

"In the last war, we ended by producing planes at the rate of 100,000 a year, but some of the heartbreaking preliminaries have been forgotten. For instance, take the B-29, which was designed well before Pearl Harbor. In May, 1942, a schedule was set up for the production of B-29's in the calendar year 1942, and we were then in all-out war with all our energies devoted to military production. The schedule called for the making of 522 B-29's in 1943. Do you know how many we actually produced? Just 92, or less than 20 per cent of schedule.

"The problems confronting us as we turn to jet aircraft are illustrated by a comparison between the old P-51 and the new jet F-86. The latter weighs about half as much more. Horsepower of the P-51 was 1,461; of the F-86, 10,400. The P-51 air frame cost $14,000; the F-86 air frame, $48,000.

"An even more eloquent comparison is that, while it took 41,800 engineering man-hours to develop the P-51, the first F-86 required 1,137,000 man-hours—27 times as many.

"The amount of material that goes into some types of jet planes is three or four times as great as the amount of material that went into an old-type plane of the same class. The cost of the electronic equipment alone in some of the new jet bombers is more than the entire cost of two B-29's.

"The revolution in aircraft extends not only to the manufacture of jet engines and frames, but to matters of armament and fire control. When airplanes can fly as fast as sound, it is obvious that the human eye, ear, and hand must be supplemented by electronics. When two airplanes rush at each other at a rate of 600 m.p.h. each, they are coming together at the flashing speed of one-third of a mile per second. And one minute after they scream past they are 20 miles apart. I imagine that even sharpshooters like Buffalo Bill and Annie Oakley would have trouble hitting such fast-moving targets.

"So, along with the jet engine revolution we have also the electronics revolution. Electronics must find the target, direct the gun, and pull the trigger. As an example of what electronics development involves, I quote from a recent statement by General Gordon Blake, Chief of the Weapons Components Division at Wright Air Base. General Blake said:

> Modern armament systems make extensive use of electronic techniques. It has been these electronic components which have given trouble due to temperature, humidity, altitude, and vibration found in aircraft installations. The principal, but by no means the only culprit, is the vacuum tube. . . If I seem to single out electronics as 'the skunk of the garden party,' it is only because it is our largest single area of trouble.

"As you know, I am an optimist. If I weren't one, I'd have to learn how to be one. My life has been spent in solving production difficulties, and I am not going to quit now. But I wish people would get the idea that, when Congress appropriates money for clouds of jet planes to be directed by electronic elves, you don't order them from a Sears-Roebuck catalog and expect delivery by return parcel post.

"Although work on small numbers of many of the fantastic weapons we are now developing had already begun, the money for the mass procurement of large numbers of these weapons was appropriated by Congress only last year. It takes just a little time to draw contracts, create designs, manufacture new types of machine tools, assemble expert man power, and take the other steps that must precede mass production.

"In due course, however, our fighting forces are going to be equipped with the most powerful and ingenious weapons ever imagined, and let me add, with all the fervor of which I am capable, I hope they will never have to be used.

"Moreover, I am not so much concerned about our ability to reach the production goals of defense mobilization as I am about the mobilization of America's spiritual power to meet the challenge that has been thrown to us by the Soviet Union. I should like to quote what two historic warriors, men who had discovered the limitations of physical force, had to say on that score.

"Napoleon said: 'There are only two powers in the world—the sword and the spirit, in the long run, the sword is always beaten by the spirit.'

"Marshal Foch said: 'The human soul on fire is man's greatest weapon.'

"We have taken liberty for granted and all the blessings that go with it. It is hard for us to realize that these rights of free men, which the founders of our country called inalienable, are actually in jeopardy. But already they have been taken away from 800,000,000 people all over the world, and they would be taken away from us if Moscow had its way.

"A full awareness of this danger would mobilize our spiritual forces in such a way as to make the ideals of democracy invincible. It is that great truth that gives meaning and power to the task of defense mobilization."

## Deceleron—A Feature of the F-89 Scorpion Control System

(*Continued from page 36*)

pletely overcome such tendencies without sacrifice of speed and maneuverability or the development of any detrimental characteristics.

Still another advantage of the deceleron which gives additional combat effectiveness is an improvement in aileron control at high speeds when the deceleron is used. This has been substantiated by wind-tunnel tests of the Scorpion's combination aileron-speed brake in comparison with other airplanes. Also noted in wind-tunnel tests was an increase in maximum lift coefficient, allowing more load factors to be pulled for normal forces below the buffet boundary.

Both structurally and aerodynamically, the deceleron demonstrates numerous advantages over other types of speed brakes. Outer wing installations of speed brakes, such as the finger type or single-flap type, occupy space that can be used, as in the Scorpion, for fuel cells. They also present structural design problems that do not exist when a speed brake such as the deceleron is used.

The employment of speed brakes such as the double split-flap type on the inboard section of the wing presents aerodynamic problems not encountered with the deceleron. Tail buffet is likely when inboard wing-speed brakes are used, and any design compromise that must be used to eliminate that possibility may result in a less effective speed brake.

The deceleron does not produce large trim changes characteristic of some types of fuselage speed brakes. The only effect of full application of the deceleron is a mild pitch-up that is easily controllable. A more rigid fuselage may be constructed when fuselage speed brakes are not incorporated, with a consequent reduction in aeroelastic problems and an appreciable weight saving.

One of the most important of the deceleron's advantages is its ability to effect rapid deceleration at the critical time during the firing approach curve without changing the trim of the airplane. The deceleron can be opened under these conditions without altering the airplane's course or attitude. Trim changes are negligible.

The use of the deceleron in high angle dives results in such effective speed reduction that dive recovery is no problem. The effectiveness of the deceleron is demonstrated by the fact that the Scorpion can make extended vertical dives at speeds well under the airplane's limiting Mach Number.

Lateral control is considerably improved in the combat speed ranges by using a slight amount of deceleron opening. This is important in evasive maneuvering when an increased rate of roll is highly desirable.

The deceleron has also proved to be of considerable benefit during all phases of landing procedures. For example, when the airplane enters the flight pattern at a relatively high speed, this device will permit rapid deceleration without reducing engine power to a minimum. Full deceleron opening can be used without any sacrifice of lateral control. After the wheels touch the ground, the decelerons rapidly reduce the airplane's speed to the point of maximum wheel brake effectiveness.

In practical application, the Scorpion's decelerons are proving to be one of the most effective speed-brake designs yet developed for fighter-interceptor aircraft.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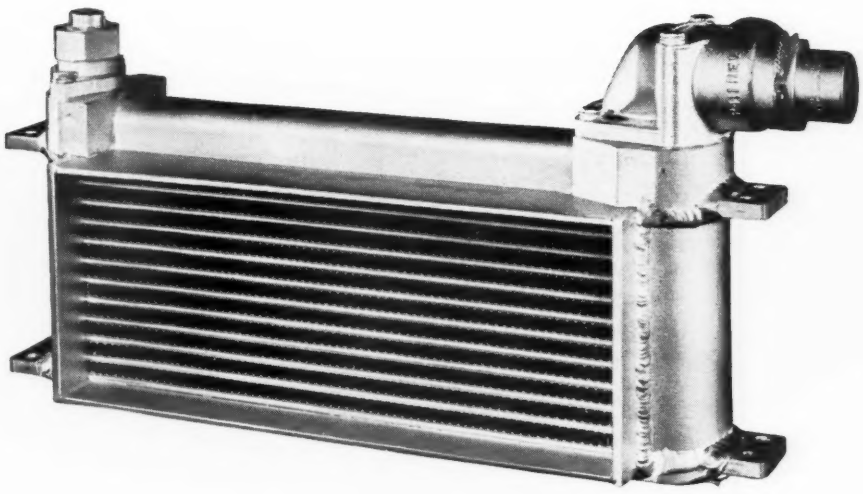

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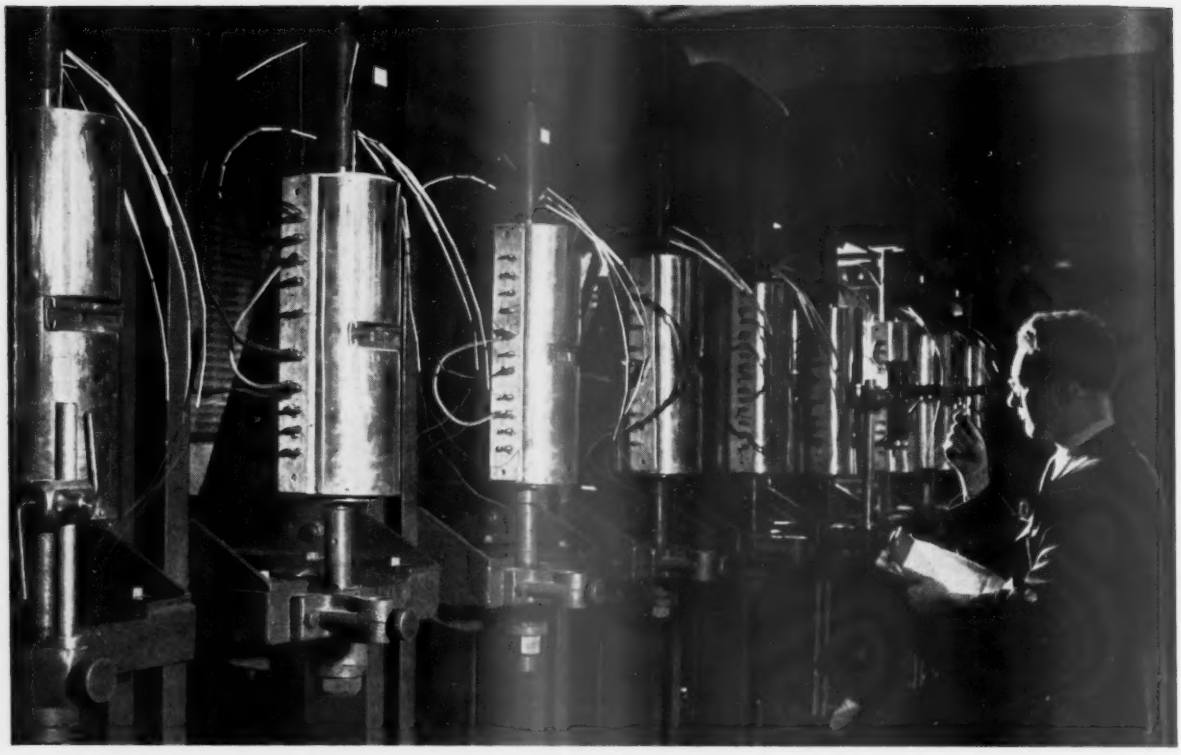

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# I.A.S. Previews

*Summaries of Current Papers Accepted for I.A.S. Publications*


## A Theory of the Direct and Inverse Problems of Compressible Flow Past Cascade of Arbitrary Airfoils


*By*

**Chung-Hua Wu and Curtis A. Brown**

*Lewis Flight Propulsion Laboratory, N.A.C.A.*


A simple unified approach to the inverse and direct problems of compressible flow past cascade of arbitrary airfoils is presented. In this approach, the close relation between the shapes of the mean line of the blade and mean streamline in the channel and that between the variations in channel width and specific mass flow on the mean streamline are utilized. The customary assumption of a linear relation between pressure and specific volume is not required in this approach, and the computations involved are also relatively simpler and quicker. The method is particularly useful for high solidity blades.

In the inverse problem, with the inlet and exit angles, a desirable blade thickness distribution, and either a desirable mean line of blade or a certain mean streamline shape chosen, the flow along the mean streamline can be properly determined and easily extended out along the pitch direction by the equations of continuity and motion. The blade boundaries are then determined from the inlet mass flow and best velocity distribution over the blade. For a quick approximate solution of the direct problem, the same process is used with one or more adjustments on the mean streamline to get the right blade shape. The solution obtained in this manner can also be used to give a good starting value for a more accurate solution by either relaxation method for hand computation or matrix method for automatic machine computation, which are also briefly described.

The theory is illustrated with solutions of both inverse and direct problems of compressible flow past typical turbine cascades of highly cambered thick blades in which accurate results are obtained by using three terms in the series. The results compared well with experimental data. The method is directly applicable to two-dimensional flows on cylindrical surfaces in axial turbomachines and can be extended to two-dimensional flows on arbitrary surfaces of revolution in radial and mixed-flow turbomachines. Families of blade sections for these machines can be built up by this method in a simple manner.

*Preprint No. 326*

## A Study of Transonic Gas Dynamics by the Hydraulic Analogy


*By*

**E. V. Laitone**

*University of California at Berkeley*


The theory governing the propagation of surface water waves is analyzed to show that an analogy with the two-dimensional flow of a perfect gas exists only if the water depth is approximately $\frac{1}{4}$ in., the model is fairly large, and the shock waves or hydraulic jumps present are of the weak type having a negligible increase in entropy.

Photographs of the water surface waves corresponding to shock waves in front of simple wedges and circular cylinders are presented to illustrate these restrictions. It is pointed out that the surface wave group velocity, which could be considerably less than the so-called wave velocity, provided the only correct analogy to the speed of sound in two-dimensional gas flow over a closed body.

Motion pictures were taken in order to study the effect of constant acceleration on bow shock waves. It was found that at high rates of acceleration the location of a detached shock wave was dependent mainly on a nondimensional acceleration parameter and was practically independent of the instantaneous Mach Number.

## A Preliminary Study of Reynolds Number Effects on Base Pressure at $M = 2.95$


*By*

**Seymour M. Bogdonoff**

*Princeton University*


A preliminary study was carried out to determine the effect of Reynolds Number on the base pressure of a simple cone-cylinder body of revolution. Tests were made at $M = 2.95$ over a range of Reynolds Numbers from $0.6 \times 10^6$ to $18 \times 10^6$. The body was tested in the smooth condition and with transition fixed by several different roughness bands. On the bases of these tests, the following conclusions were reached:

(1) The variation of base pressure with Reynolds Number is characterized by three distinct regions: (a) a "laminar" region where the free wake appears to be laminar and where increases in Reynolds Number give large decreases in base pressure, (b) a "transitional" region where transition from laminar to turbulent flow seems to be occurring in the free wake and where increasing Reynolds Number causes a leveling off from the laminar region and then a sharp increase in base pressure, and (c) a "turbulent" region where the boundary layer on the rear of the body is turbulent and where increasing Reynolds Number results in a slow but steady decrease in base pressure.

(2) Extrapolation of data in regions (a) or (b) of (1) will not give valid results at higher Reynolds Numbers. For the body tested, data above $6 \times 10^6$ are needed to predict base pressures accurately at high Reynolds Numbers.

(3) The use of transition bands of the type tested on the body at low Reynolds Number gave results that could not be correlated with data obtained on the smooth body at high Reynolds Number. The base pressure depends critically on the ratio of band thickness to body diameter.


Please do not order Preprints of these papers at this time.
See page 87 for Preprints that are immediately available.


## Experiments on Interaction of Shock Waves and Cylindrical Bodies at Supersonic Speeds


*By*

**M. V. Morkovin, E. Migotsky, H. E. Bailey, and R. E. Phinney**

*University of Michigan*


While two-dimensional shock wave reflections have received much attention, in most applications either the shock surface or the reflecting surface is curved. Elements of nonviscous theory for three-dimensional shock reflections by two of the

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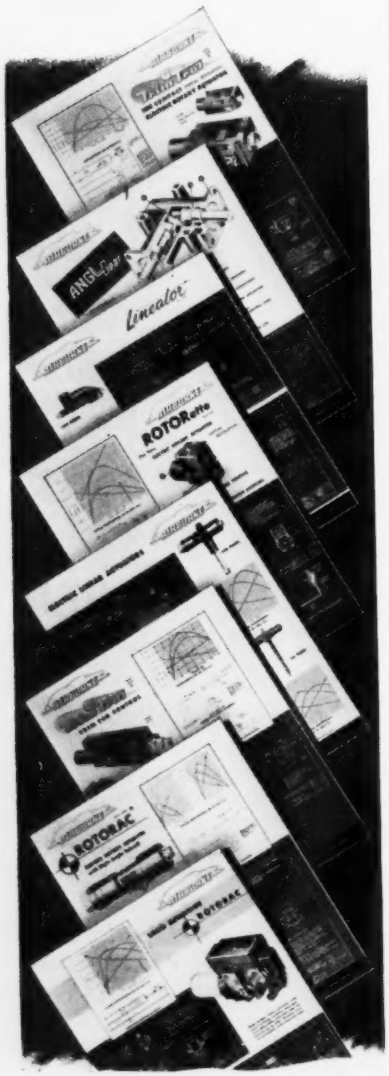


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present authors indicated the likelihood of anomalous reflection for configurations such as that of a plane shock impinging on a cylinder aligned with the free stream. This paper presents the highlights of the experimental investigation of this three-dimensional shock-cylinder configuration conducted in the University of Michigan Supersonic Wind Tunnel at Mach Number 1.90.

One general result is the striking boundary-layer cross flow induced by the sharp pressure gradients across the reflection line on body surfaces. For the present configuration, the cross flow, in and outside of the boundary layer, results in a separated region on the lee side of the body. The effects of boundary-layer character and thickness and of shock strength on the overall flow and pressure fields are studied by means of body pressure distributions and several visualization techniques. Implications of the present findings for practical applications are discussed.

## The Measurement of Downwash and Sidewash Behind a Rectangular Wing at a Mach Number of 1.6

*By*

**Theodore Davis**

*United Aircraft Corporation*

Downwash and sidewash angles were measured with a conical probe in vertical planes 0.5, 1.0, and 1.5 chord lengths downstream of a rectangular wing of biconvex section. Finely spaced measurements were taken to determine the downwash field in the region of steepest gradients with the result that the rolling up of the vortex sheet was well defined. The experimental results are compared with the theoretical solutions calculated from the measured wing loading.

The Mach Number and dynamic pressure in the empty tunnel and behind the wing were also determined. The free-stream Mach Number was 1.60 and the Reynolds Number, based on wing chord, was $0.58 \times 10^6$.

## Remarks on Dynamic Loads in Landing

*By*

**Adam Zahorski**

*North American Aviation, Inc.*

Engineering aspects of the solution of the equation of motion for the inertia forces on an aircraft wing during the impact of landing are presented. A new and simplified, yet rigorous, approach to the analysis of dynamic loads which can be easily applied to an arbitrary forcing function is described. Working limits are established for the number of modes of vibration which are effective in contributing to the dynamic responses. Examples are given to show how the inertia forces are affected by different modes of vibration, by variation in mass distribution, and by shapes of the forcing function.

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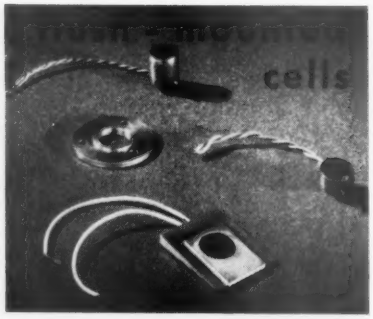


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# American Helicopter Society News

## Joint A.H.S.-I.A.S. Meeting

More than 50 members attended and participated in the joint meeting of the American Helicopter Society and Institute of Aeronautical Sciences at the St. Louis Engineers Club on December 11. Lt. Colonel David E. Condon, Engineering Officer, Air Training Department, Fort Sill, Okla., was guest speaker on invitation of the Mid-West Region, American Helicopter Society.

Colonel Condon presented a comprehensive paper, "Helicopter Maintenance and Future Requirements." His paper was based on the extensive helicopter training operations at Fort Sill. Thirty-one helicopters have operated more than 2,000 hours in one month for the training of Army helicopter pilots who, with other service helicopter pilots, are doing such an outstanding job in Korea. As Engineering Officer, Colonel Condon is responsible for the maintenance of not only the helicopters but of the 160 training and liaison aircraft. It was disappointing to learn that the helicopters, operated only approximately 10 per cent of the total time, required approximately 50 per cent of the total maintenance for all aircraft. Colonel Condon and his group have collected complete factual helicopter maintenance data. Although he was unable to include such data because of security restrictions, he presented an informative and interesting picture of the difficulties of operating present-day helicopters. The lack of replacement parts and the relatively low availability were cited as major difficulties.

Colonel Condon outlined his ideas of the possible future requirements of future service helicopters of small, intermediate, and large sizes. He emphasized the necessity of simplification of design, ease of operations under combat conditions, reduced maintenance, and increased availability. Korea has proved the helicopter's usefulness to the U.S. Army; its operation and potential will be expanded when improved models of rotary wing aircraft are in production.

A question and answer period after Colonel Condon's presentation brought forth many interesting questions. The mechanical complexity of current production helicopters makes it difficult for engineers and others not directly associated with the helicopter industry to recognize the great potential of efficient rotary wing aircraft. However, it was generally indicated that rotary wing aircraft could be and should be simplified. Quantity production of rotary wing aircraft will increase the rotary wing potential.

Fred Schroeder, Bell Aircraft Corporation, represented the Great Lakes Region of the American Helicopter Society.

C. R. Wood, Jr.
A.H.S. Mid-West Regional
Vice-President

**A HELICOPTER ON MT. WASHINGTON KEEPS WARM**

*Complete protection against freezing weather is provided for the experimental Bell helicopter on the summit of Mt. Washington by complete covering between test runs. Shown with the ship are members of the Bell Aircraft experimental crew.*

## Great Lakes Section

A dinner meeting of the Great Lakes section of the American Helicopter Society was held in Buffalo, Monday, January 7, where more than 100 members and guests dined at the Park Lane Hotel.

Presiding over the session, which included the presentation of two papers, was R. Allen Price, Parsons Industries, Great Lakes Regional Vice-President.

The first paper, by Owen Q. Niehaus, Bell Aircraft Corporation, was entitled "Helicopter Maneuver Loads in Relation to Recent Specifications and Tests." A film was shown of flight tests in which a Bell 47D-1 helicopter was flown in a series of repeated runs near the ground at maximum speed toward a 50-ft. tree. Two hundred feet from the tree the pilot executed an abrupt climbing turn to right or left, or a straight pull-up over the tree. The maximum load factor observed during this demonstration was approximately 2.1 with an oscillatory component of $\pm 0.2$.

The second paper, by Lt. Commander Houser, Bureau of Aeronautics, and Robert R. Lynn, Bell Aircraft Corporation, was entitled "Results of Recent Rotor Blade De-Icing Tests on Mt. Washington."

The authors presented strong experimental evidence in favor of *de*-icing as opposed to *anti*-icing, the latter being subject to the disastrous "run-back" phenomenon—too much heat can be worse than none at all.

The experiments were run with electrically heated rubber "boots" on the blades. Longer cycling times required less power density, but if the cycling time was made too long, the resulting vibrations and power loss became excessive.

Flown from Buffalo to the summit of Mt. Washington by Bell Pilot Richard Buyers, the test helicopter experienced no loss of power resulting from the rotor blade deicing boot installation.

Paul Marcott
A.H.S. Publicity Chairman

**A.H.S. Eighth Annual Forum**

May 15 and 16, 1952
The Washington Hotel
Washington, D. C.

## I.A.S. News (Continued from page 29)

Formerly, Chief Structures Engineer, Aircraft Armaments.

**F. C. Hallowell, Jr.** (T.M.), now Aero. Engineer, Analytical Computer Group, Naval Air Development Center, Johnsville, Pa.

**Second Lieutenant Read Johnson, Jr.,** U.S.A.F. (T.M.), now at A.F. Missile Test Center, Patrick Air Force Base, Fla.

**William D. Kennedy** (A.F.), General Manager, Bristol Aeroplane Engines (Western) Limited, Vancouver, B. C., Canada. Formerly, Vice-President and General Manager, Wright Aeronautical Corporation, Curtiss-Wright Corporation.

**J. Francis Maloney** (M.), Group Engineer, Aircraft Armaments, Inc. Formerly, Group Engineer, Production Design Section, The Glenn L. Martin Company.

**John B. McPherson** (A.M.), Design Engineer, Brooks Rotameter Company. Formerly, Vice-President and Chief Engineer, Air-Shields, Inc.

**John R. Meyer, Jr.** (T.M.), Engineer, Nagler Helicopter Company, Inc., Boston. Formerly, Engineer, Massachusetts Institute of Technology.

**Joseph P. Paine** (M.), Chief Project Engineer, Aircraft Armaments, Inc. Formerly, Chief Electro-Mechanical Engineer, Aircraft Armaments.

**G. B. Saksena** (A.F.), Senior Stressman, Canadair, Ltd. Formerly, Assistant Chief Stressman, de Havilland Propellers, Ltd.

**Dr. Martin De Puy Schwartz** (M.), Operations Analyst, Operations Analysis Office, Headquarters, Strategic Air Command, Offutt Air Force Base, Neb. Formerly, Project Leader, Aero-Elastic and Structures Research, Massachusetts Institute of Technology.

**Lieutenant Donald H. Sotanski** (T.M.), Student Officer, 3306 Plt. Trng. Sqd., Class 52-H, Bainbridge Air Force Base, Ga.

**Donald B. Talmage** (M.), Engineering and Maintenance Staff, Air Transport Association. Formerly, Aeronautical Research Scientist and Member of Headquarters Technical Staff, N.A.C.A.

**R. J. Tatge** (M.), now Assistant Wright Field Representative, AiResearch Manufacturing Company.

**Paul Torda** (A.F.), now Professor of Aeronautical Engineering, Department of Aeronautical Engineering, University of Illinois.

# Corporate Member News

• **Aircraft Radio Corporation**...William F. Cassedy, Jr., assumed the office of President on January 1. Mr. Cassedy succeeds Lewis M. Hull, A.F.I.A.S., who was elected Chairman of the Board and re-elected Treasurer.

• **AiResearch Manufacturing Company, Division of The Garrett Corporation**... Plastic tooling is now being used at AiResearch. Plaster cores for impeller blade assemblies are being formed in plastic molds. The new molds have yielded an increase of over 1,300 per cent in parts produced per tool, as compared with the formerly used molds of dental stone. The material used in the new molds is Tool-Plastic, a thermosetting liquid phenolic resin supplied by Rezoline, Inc., of Los Angeles. Tolerances of 0.005 in. have been obtained through the use of Tool-Plastic Molds.

• **Aluminum Company of America**...A new product, designated "Alcoa Utilitube," is a general-purpose aluminum coiled tube made of new Alcoa aluminum alloy B50S-O. Alcoa Utilitube, which has many advantages, can be used in fuel oil, gasoline, and lubricating oil lines for internal combustion engines; in fuel gas lines for stoves and heaters; and in air, vacuum, and hydraulic lines for brakes and instruments. A booklet on this product may be had by writing the company at 683 Gulf Building, Pittsburgh 19...Dr. Francis C. Frary, Director of Research, retired on January 1.

• **American Airlines System**...American has placed a $39,750,000 order with Douglas Aircraft Company for 25 of the recently announced DC-7. (See three-view drawing of the DC-7 on page 65). Delivery of the DC-7's is expected to begin late in 1953; regular transcontinental service is scheduled to be inaugurated on January 1, 1954.

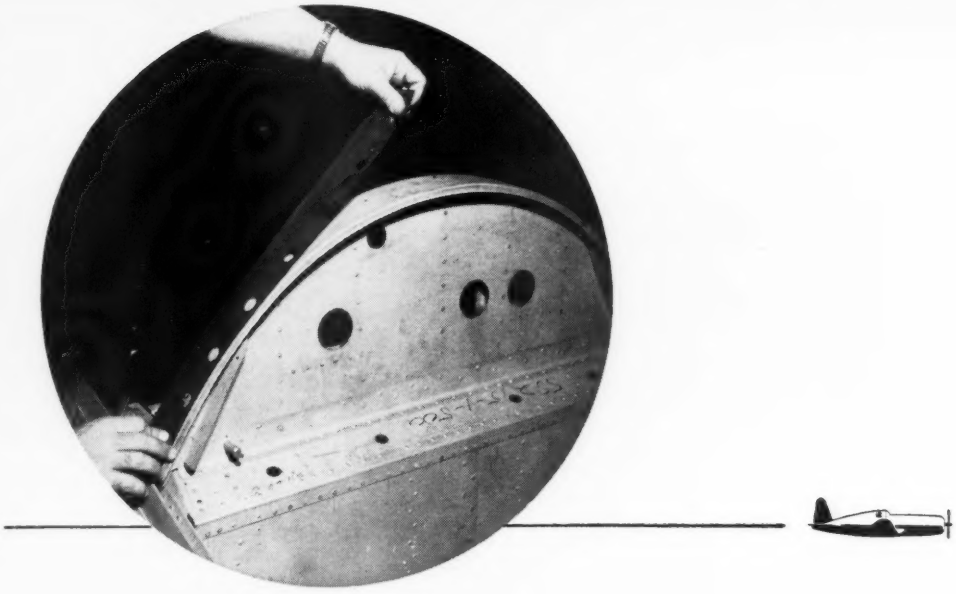
• **Beech Aircraft Corporation**...The U.S. Army Ground Forces have contracted for the purchase of four Beechcraft Model 50 Twin-Bonanzas, designated the YL-23... A contract has been received from the Canadian government for the modernization of 83 Royal Canadian Air Force C18S Beechcrafts. The aircraft will be modernized in accordance with the latest D18S configuration at the factory of MacDonald Brothers Aircraft Limited, Winnipeg, Canada.

• **Bell Aircraft Corporation**...The development of what is said to be the first successful deicing system for helicopter rotor blades was recently announced. The deicing system, operated electrically, consists principally of rubber "boots" running the entire length of the main rotor blades and covering about one-third of the surface. The system was developed for the U.S. Navy Bureau of Aeronautics and is reported to cause no adverse effects on the normal flight characteristics of the helicopter.

• **Boeing Airplane Company**...The following changes in management organization, effective January 1, 1952, were designed to bring about the closest possible coordination between engineering and manufacturing functions and between the Seattle and Wichita divisions. Wellwood E. Beall, I.A.S. Fellow and President, who was formerly Vice-President—Engineering and Sales, has been named Senior Vice-President. He is responsible for the general direction of manufacturing, engineering, and various related functions at Seattle and the general supervision of the Wichita activities. C. B. Grace, formerly Vice-President—Operations (Seattle), was named to the newly created position of Vice-President—Manufacturing, Wichita Division. Clif Barron was moved from Vice-President—Assistant General Manager, Wichita Division, to Vice-President—Divisional Controller, Wichita, with the discontinuance of Mr. Barron's former position. Mr. Barron was also made Assistant Secretary and Assistant Treasurer of Boeing. Clyde Skeen, formerly Assistant Secretary-Treasurer in charge of financial functions at Wichita, became an Assistant to the Vice-President—Controller, Seattle. Jack Clark, formerly Assistant to the Factory Manager, Wichita, was made Modification Center Manager in charge of B-47 modification activities. N. D. Showalter, formerly Assistant Chief Engineer, Wichita became Chief Engineer, Wichita. All functional division heads at Seattle have assumed the policy direction of similar functions at Wichita; these include: E. C. Wells, M.I.A.S., Vice-President—Engineering; F. P. Laudan, Vice-President—Manufacturing; J. O. Yeasting, Vice-President—Controller; A. F. Logan, Vice-President—Industrial Relations; H. E. Bowman, Secretary-Treasurer; George Sanborn, Director of Spares; E. P. Kaiser, Quality Control Manager; and Harold Mansfield, Director of Public Relations and Advertising. The Sales Division and the Industrial Products Division do not have corresponding departments in Wichita...According to a report, recently completed tests have proved that the Boeing C-97 Stratofreighter can be used as a forward-area supply transport. During these tests, the Stratofreighter acted as a paradrop cargo carrier and also demonstrated its capabilities to handle many new items of Army Field Forces equipment. This double-deck ship is already in use as a cargo-plane troop carrier, hospital ship, staff and communications transport, personnel transport, and aerial tanker.

• **Consolidated Vultee Aircraft Corporation**...A 400,000-lb. pinch-type bending roller for rolling contours on B-36 wing skins has been installed at the Fort Worth Division. The machine measures 51 ft. in length and is mounted in a $5^1/_2$-ft. hole dug beneath the plant floor to allow for the easy feeding of sheet aluminum into the three rollers, 31 ft. long. The bending roller is also capable of shaping cones and rolling other types of materials. The machine was manufactured by Bertsch and Company; its delivery to Convair was expedited through the Ford Motor Company, which permitted its order for a comparable machine to be delivered to Convair. Ford will get its machine in the early part of 1952.

• **Douglas Aircraft Company, Inc.**...A newly developed radio-controlled life raft for air-seas rescue is contained in an aluminum alloy cylinder that may be launched



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• **Fairchild Aircraft Division, Fairchild Engine and Airplane Corporation, and General Electric Company**...Engineers from both companies have designed an X-ray unit that is said to speed up the analysis of approximately 2,000 castings used in each C-119 Flying Boxcar. This new equipment, known as G-E's OX-140 KV unit, features a lead-lined X-ray cabinet, with automatic closing doors, which is manually fed trays full of metal castings. A Pako Filmachine develops one film every 60 sec. for radiographic inspection.

• **Fairchild Engine and Airplane Corporation**...Arthur F. Flood was elected Executive Vice-President of the corporation. Mr. Flood was formerly Vice-President and Comptroller of Fairchild.

• **Flight Safety Foundation**...Jerome Lederer, F.I.A.S., Director of the Foundation, presented Awards of Merit to Melvin F. Fisher and Robert J. Cramer, C.A.A. Aircraft Communicators at Columbus, Ohio. The awards were earned by Messrs. Fisher and Cramer on April 30, 1950, when they spent two hours in the C.A.A. Communications Station saving a pilot lost in bad weather.

• **General Electric Company**...A four-jet North American B-45 bomber under bailment from the U.S. Air Force has been placed in full operation by G-E by the Flight Test Division. The bomber will be used as a flying test bed and will carry the fifth engine in a specially designed nacelle under the bomb bay. Among the engines to be tested by this "jet laboratory" are the J-73 (originally the J-47-21) and the J-47-GE-17 reheat engine.

• **Hamilton Standard Division, United Aircraft Corporation**...Aircraft cockpit refrigeration units have been ordered by the U.S. Air Force and U.S. Navy and, according to present plans, will be installed into seven types of aircraft, including jet fighters and turboprop transports. In the majority of instances, this order is confined to the function of supplying cooling air to the aircraft cockpits.

• **Jack & Heintz, Inc.**...A newly developed standard electrical control system for aircraft generators, designated GC34-1, can be installed on many types of aircraft and is physically and electrically interchangeable with systems of other manufacturers. The Jack & Heintz system is designed to give continuous control and protection to generators under rugged altitude and temperature conditions. Mounted on a simple panelized mounting tray for easy installation and servicing, it has only one external cable. An aircraft engine-

driven generator, main contactor, two 250-millivolt shunts, and generator switch operate in conjunction with the panel and constitute the complete generator control system.

• **North American Aviation, Inc.**... The XA2J-1 Savage, a turboprop carrier-based attack bomber, was flown from Los Angeles International Airport to Edwards Air Force Base, Calif., early last January for further testing. The XA2J-1, powered by two Allison T-40 turboprop engines, has a maximum take-off gross weight of more than 26 tons. It is capable of carrying a 5-ton bomb load and is equipped with 20 mm. guns. It carries a crew of three... Preflight work on the F-86D Sabre has been started in two hangars located at Los Angeles International Airport... The new facility at Fresno, Calif., is to be used primarily for the future modification and modernization of completed aircraft.

• **Pan American World Airways, Inc.**... DC-6A all-cargo service was begun on Pan Am's Atlantic route last January 5. The DC-6A flights, which will operate from the United States on Saturdays and from Europe on Sundays, will provide a pressurized cargo space, capable of carrying animal and perishable shipments... A direct all-cargo sheduled service was inaugurated on January 10 between New York and San Juan. The DC-6A transports are being used on the flights, leaving New York on Thursdays and San Juan on Fridays.

• **Pratt & Whitney Aircraft Division, United Aircraft Corporation**... A contract "to work on the development of an atomic aircraft engine" has been awarded to Pratt & Whitney. A similar contract was recently given to General Electric Company for the development of a nuclear-propulsion engine for an aircraft to be constructed by Consolidated Vultee Aircraft Corporation. Air Force officials are said to have stated that Pratt & Whitney's proposed engine is intended for "another aircraft" and that the two engine projects were "not competitive" but merely "two different technical paths to the same end." The Atomic Energy Commission is cooperating in consideration of the nuclear-energy phase of the work. The project will be under the technical supervision of Wright A. Parkins, Engineering Manager, and Perry W. Pratt, M.I.A.S., Assistant Chief Engineer... The U.S. Navy is substituting Pratt & Whitney T-34 Turbo-Wasp turboprop engines for the present power plants in two Lockheed R70-1's, the Navy version of the new Super Constellations. This engine replacement represents part of a program designed to test turboprop-powered transport aircraft. One of the R70-1's will be assigned to the Naval Air Test Center, Patuxent River, Md.; the other will remain at Lockheed Aircraft Corporation for continued development testing. The U.S. Air Force, in order to test the potentialities of turboprop-powered transports, is installing T-34's in a Douglas C-124 Globemaster. This particular model of the Globemaster is to be known as the YC-124B.

•

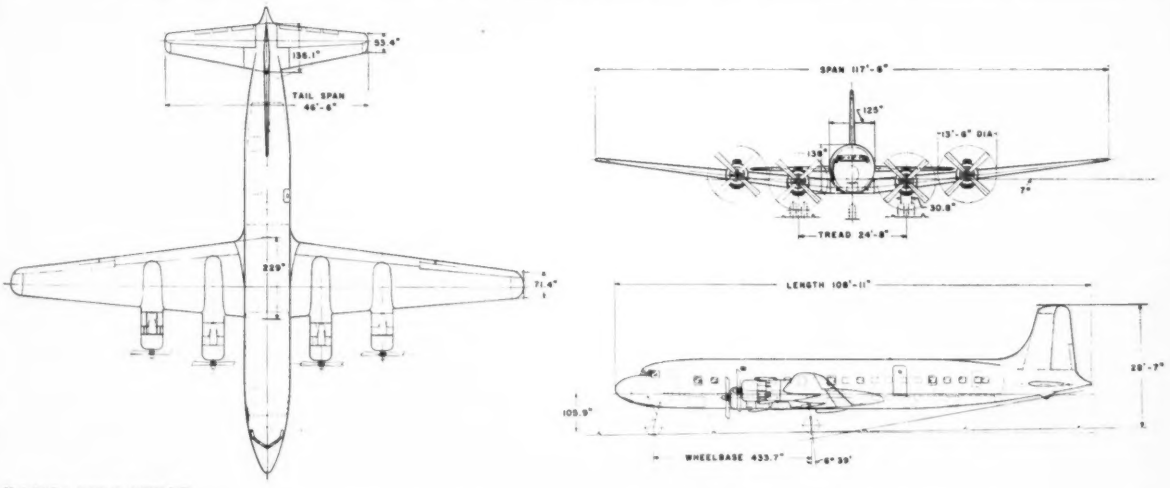
• **Republic Aviation Corporation**... A big three-phase frequency converter spot welder is joining high-strength aluminum alloy thicknesses in combinations up to $^1/_4$ in.–$^3/_8$ in. and is averaging more than 80 spot welds a minute on wing skins. This accomplishment is a result of the company's Machine Capability Exploration program that suggested refinements for the welder, built by Sciaky Brothers, Inc.... The General Services Administration plant at Manor Haven, L.I., N.Y., has been leased for the manufacture of F-84 wings and other components. This particular plant was operated during World War II by Grumman Aircraft Engineering Corporation.

• **Seaboard & Western Airlines, Inc.**... Two $2,000 fellowships have been established in Columbia University's Graduate School of Business by Seaboard & Western. The two grants will begin with the 1952–1953 academic year and are to provide for study and research on international air freight across the North Atlantic. Holders of the grants will study international trade and geography, marketing, and transportation.

• **Seaboard & Western Airlines, Inc., and Lockheed Aircraft Corporation**... Seaboard & Western has placed a $10,000,000 order for five Lockheed 1049B Super Constellation all-freight aircraft to be powered with Wright R-3350-30W Turbo Compound engines. According to Robert E. Gross, Lockheed's President, this transaction "marks the first purchase by a commercial airline of new, long-range, all-freight aircraft for over-ocean operation." Seaboard's President Raymond A. Norden stated that these ships will be operated between the United States and points in Western Europe and the Middle East. The airplane using the Wright compound engine will carry 6,570 U.S. gals. of fuel and will be authorized, it is said, for operation at the following weights: maximum zero fuel, 105,000 lbs.; maximum landing, 110,000 lbs.; and maximum take-off, 130,000 lbs. The modification of the airplane for turboprop engines will make possible an increase in the maximum take-off weight to 150,000 lbs.

• **Socony-Vacuum Oil Company, Inc.**... An unrestricted gift of $100,000 was made to the proposed $22,150,000 Engineering Center at Columbia University. This money is believed to be the largest unrestricted gift presented to an educational institution by a private corporation.

• **Solar Aircraft Company**... A new Orenda engine was flown from Toronto to San Diego in a Royal Canadian Air Force four-engined transport. It will be used by




**DOUGLAS' LATEST**

*Douglas Aircraft Company, Inc., has announced the details of its latest model of its series of commercial transports, the DC-7. This ship, which can accommodate from 60 to 90 passengers, is powered by four Wright compound engines. The absolute range of the craft with 4,512 gals. of fuel on board is 3,625 miles at 10,000 ft. and 3,500 miles at 20,000 ft. With 6,600 gals. in the tanks, the absolute range is raised to 5,350 miles at 10,000 ft. and 5,175 miles at 20,000 ft. It has a maximum take-off weight of 116,800 lbs. in domestic service and 122,200 lbs. for overseas work. Its top speed will be in excess of 400 m.p.h. and normal cruising speed will be more than 360 m.p.h.* *(See American Airlines System, page 62).*

Solar in the development of an afterburner for the Canadian power plant.

• **Union Carbide and Carbon Corporation**... James A. Rafferty, 65, Vice-President and Director of the Corporation, died in Fort Lauderdale, Fla., on December 19. Elected President of Carbide and Carbon Chemicals Corporation in 1929 and of Bakelite Corporation in 1939, he was made Chairman of the Board of both subsidiary concerns in 1944. He also held other top positions in Union Carbide and Carbon and its subsidiaries. Mr. Rafferty was named Vice-President of Union Carbide and Carbon in 1938 and a Director in 1944.

• **Vickers, Inc.**... The 1951 Transport Aircraft Hydraulic Accessory and Systems Conference, sponsored by Vickers, was held on December 4 and 5 in Detroit. This conference, which was attended by about 80 persons, is the first of a proposed series of Vickers-sponsored open-forum discussions of all phases of aircraft hydraulic systems.

• **Wright Aeronautical Division, Curtiss-Wright Corporation**... The R-3350-30W Turbo Compound engine will be used to power the ten Lockheed 1049B Super-constellation all-freight transports ordered by Seaboard & Western Airlines, Inc., as well as the 25 Douglas DC-7's ordered by American Airlines System.

# *Meet Your Section Chairman*

## Paul L. E. Alberti

Texas Section

Paul L. E. Alberti and his wife, the former Rosamond "Scotty" Scott whom he married in 1942, have a foolproof method of preventing "too many dull moments" in the course of everyday life. It takes the form of "two wonderful redheads," Scott, aged 5, and Paul Wendell, aged 1. As a matter of fact, the two boys constitute one of his ways of recreation. The others are things like reading, playing golf (at which he claims to be a dub), motoring with his wife, fooling around with his camera, and sports (which he says he now takes on mostly as a spectator). At one time he did a great deal of saltwater sailing, but his present habitat "Deep in the Heart of . . . ." made this hobby "a little hard to do."

Charles Lindbergh's flight in 1927—Paul Alberti was then 8 years old—was the paramount factor in focusing his attention on the idea of aeronautics in his own future. Mr. Alberti tells us that aeronautics "appeared to be the most challenging branch of engineering," which he has since found to be "a satisfying, but often frustrating, business."

A native of Boston and a product of the school system of the Commonwealth of Massachusetts, he was graduated from the Massachusetts Institute of Technology with a B.S. degree in Aeronautical Engineering in June, 1940. He went to work immediately as a Draftsman for Lockheed Aircraft Corporation. In April of the following year, he transferred to Chance Vought Aircraft Division of United Aircraft Corporation. Within 5 months, he was promoted from Draftsman on fuselage design to Layout Draftsman for armament layout and design. In the spring of 1945, he became Staff Designer in the Preliminary Design Group, working first on armament studies and later on aircraft preliminary design and performance. From 1947 to 1950, he supervised a wing group that was charged with the wing design on all Chance Vought projects, such as the F6U-1, XF7U-1, and F7U-1, 2, and 3. Early in 1950, he was given the direction of preliminary design and proposal on new aircraft and a year later was promoted to his present position as Assistant Project Engineer on the development of a new type of carrier-based aircraft.

During World War II, Mr. Alberti worked for a time as a contractor's representative on experimental armament-installation test projects at the Patuxent River Naval Air Station, Md. Incidentally, he is the author of the "Aircraft Armament" section of *Collier's Encyclopedia*, published in 1950.

What has been Paul Alberti's most interesting points in his career? He has several answers to this: (1) contributing early in his career a small part to the successful development of the early multiple 20 mm. cannon; (2) his more recent association with preliminary design studies, analyses, and development of new aircraft types; and (3) his enjoyment of the interesting personalities encountered in aircraft work.

In addition to being Chairman of the I.A.S. Texas Section, Mr. Alberti is active in the Engineers Club of Dallas, the M.I.T. Club of North Texas, and the Theta Chi Alumni Chapter of North Texas.

# I.A.S. Sections

## Baltimore Section

M. Francis Taylor, *Secretary*

The thirty-third meeting of the Baltimore Section was held on December 11, 1951, at Johns Hopkins University.

The Chairman, Mr. Jewett, called the meeting to order at 8:35 p.m. There were approximately 45 members and guests present. The minutes of the last meeting were approved as read. The Program Committee Chairman then presented the guest speaker of the evening, Dr. George F. Wislicenus.

Dr. Wislicenus is Chairman of the Department of Mechanical Engineering, The Johns Hopkins University. He is consultant for several industrial concerns and Government commissions, including the A.E.C., and, among other activities, is a member of the N.A.C.A. subcommittee on Compressors and Turbines. He used as the subject of the evening's discussion, "Potential Improvements in Jet Propulsion for Transport Aircraft."

The speaker introduced his subject by pointing out that there will be a continuing need for subsonic aircraft, both military and commercial, and that the jet engine as presently developed is not efficient in the lower and middle subsonic range. He believes there is a great need for propulsion development to fit the 400 to 600 m.p.h. class of aircraft.

Dr. Wislicenus indicated the major fundamental difference between the reciprocating-engine-driven propeller air stream and the turbojet air stream is such as to preclude efficiency using the small diameter and high velocity air stream of the turbojet in the aircraft speed range being considered. The ideal propulsion system is one that pushes back the air disturbed by passage of the aircraft or returns it to normal. The speaker then went on to discuss how close in reality we can come to the ideal case. Downwash is an unavoidable power loss since it supports the aircraft. However, the drag losses could be reduced, if the propulsion system provided relatively slow-moving but large masses of air, distributed spanwise in proportion to the aircraft drag. It is important to make it clear that the air masses are large only with respect to conventional aircraft jet engines. The rate of flow is still relatively small in comparison to that handled by a standard propeller. Such an attractive solution depends upon an entirely different jet-engine development. The present trends in jet engine development stem from military needs and the reluctance to add weight and propeller complexity to the engines.

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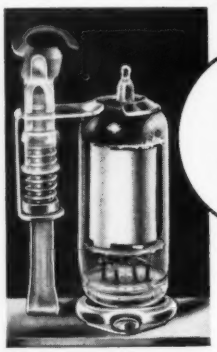

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Dr. Wislicenus indicated his belief that development of a large air-mass, relatively low-velocity jet engine, perhaps with lower thermal efficiency, but certainly with much higher propulsive efficiency, can be realized. He suggested that the power-plant system be combined with boundary-layer control to provide a truly economical system. The speaker touched briefly upon experiments at Johns Hopkins which indicate boundary-layer air can be removed and used effectively in jet engines.

In conclusion, Dr. Wislicenus asserted, the ideal propulsion system for aircraft in the 400 to 600 m.p.h. class (or any class) is one that helps return the air to normal behind the aircraft and that, to approach this ideal, a new jet power plant must be developed handling large quantities of boundary-layer air and exhausting it at lower velocities and temperatures than are now used in jets. Such a system would open up interesting possibilities in aircraft design.

Following Dr. Wislicenus' talk, the program committee presented a short color sound film produced by McDonnell Aircraft showing their small ram-jet helicopter, "Little Henry," in action.

## Boston Section

L. J. Nuttall, *Secretary*

The new officers of the Boston Section are: Chairman, C. F. Savage; Vice-Chairman, Prof. R. L. Bisplinghoff; Secretary, Prof. E. E. Larrabee; and Treasurer, J. D. Morrison.

## Chicago Section

Alfred F. Stott, *Secretary*

The Chicago Section held its regular monthly meeting at the Chicago Engineers Club on December 13. Twenty-five members met for a 6:30 dinner. Chairman Robert H. Wendt called the meeting to order at 8:15. Captain Wallace B. Mechling, U.S.N., Advisory Board Chairman, was introduced, and he in turn presented the speaker for the evening, J. T. Wills, Manager, Sales Engineer, Allison Division, General Motors Corporation.

Mr. Wills spoke on "Allison Gas Turbines" and presented an informative and practical talk starting with the history of Allison and progressing to the modern designs. A few of the interesting historical points about Allison were: the first high-speed high-load bearing in 1925; the acquisition of control of Allison by General Motors in 1929; the production of their dirigible engine

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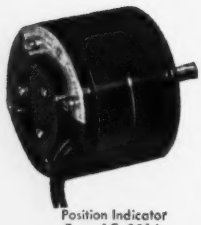

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in 1932; and their production in 1941 of 1,000 aircraft engines per month. Their V-3420 came out in 1942; in 1943, the company had stepped up war production to 2,400 engines per month. Jets began to appear in 1944; and turboprops appeared in 1949. At present, Allison is working on the T-61. Mr. Wills showed a series of interesting slides picturing various types of jet engines, fuel and power curves, production and critical material comparisons, as well as Allison installations in the various aircraft. A fine color sound movie, *Harnessed Lightning*, was shown. A most enjoyable and instructive question-and-answer period followed.

Program Chairman, Dr. H. L. Hull, thanked Mr. Wills for the fine talk and mentioned January 10 as the date of the next meeting. Chairman Wendt closed the meeting at 10:30.

## Cleveland-Akron Section

Harrison C. Chandler, Jr., *Secretary*

Dr. Edward R. Sharp, Director, Lewis Flight Propulsion Laboratory, N.A.C.A., Cleveland, was the featured speaker at the second meeting of the 1951–1952 year held on November 27 at the University Club in Akron. His paper was entitled "A Report on British and European Aviation." About 220 members and guests attended the social hour, dinner, and meeting which comprised the evening's program.

Dr. Sharp had recently returned from an extensive tour of aeronautical research and manufacturing facilities in Great Britain and Europe. He discussed the National Gas Turbine Establishment, Royal Aircraft Establishment, and National Physical Laboratory in England, comparing the nature of their work with that of similar institutions in America, such as the N.A.C.A. In this connection, he noted that the R.A.E. is now placing considerable emphasis upon the development of guided missiles.

Of the various airplane and engine manufacturers that he visited, Dr. Sharp paid particular compliments to the Bristol and Rolls-Royce companies. He said that the Rolls-Royce people attributed their great success in the aircraft engine field to their capacity for making mistakes fast and then correcting them fast. By way of support of the success achieved by Rolls-Royce, Dr. Sharp pointed out that the Avon turbojet engine is the power plant selected for just about all the new British high-speed military aircraft.

▶ The Fifteenth Wright Brothers Lecture, "The Experimental Approach to Aircraft Structural Research," by Dr. P. B. Walker, Royal Aircraft Establishment, was the feature of the third meeting of the section. This meeting, held

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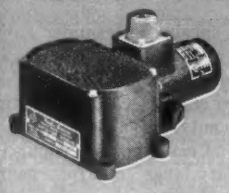

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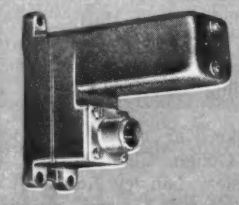

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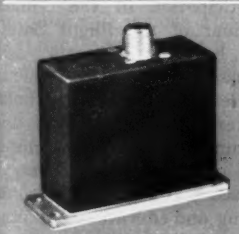

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on December 19 at the N.A.C.A. Lewis Flight Propulsion Laboratory, was attended by about 150 members and guests. A social hour and dinner at the N.A.C.A. cafeteria preceded the meeting. Unusually bad weather conditions limited the attendance.

Dr. Karl Arnstein Vice-President, Goodyear Aircraft Corporation, brought out a number of stimulating thoughts on the topic of aircraft structures in his prepared comments on Dr. Walker's paper.

## Hagerstown Section

Robert E. Braus, *Secretary*

Thirty-eight members and guests attended the December 11 meeting held in the Antrim Room of the Hotel McLaughlin, Greencastle, Pa.

The new officers who assumed their duties at this time are: Chairman, Earl E. Morton; Vice-Chairman, E. R. Gelvin; and Secretary-Treasurer, R. E. Braus.

The guest speaker, Alexander Satin, of the Office of Naval Research, read a paper entitled "Boundary Layer Control" and later showed slides illustrating important points of his subject. A film showing a Cessna airplane equipped with boundary-layer control served to emphasize further the possibilities of increased performance for aircraft to be realized through research and development.

## Hampton Roads Section

Albert L. Braslow, *Recording Secretary*

The last 1951 meeting was opened by the outgoing chairman, Charles F. Merlet, who introduced to the members and guests the newly elected incoming officers: Chairman, Melvin N. Gough; Vice-Chairman, John A. Harper; Treassurer, H. Herbert Jackson; Corresponding Secretary, Jesse L. Mitchell; and Recording Secretary, Albert L. Braslow.

The speaker for the evening was Melvin N. Gough, Chief, Flight Research Division, Langley Aeronautical Laboratory, N.A.C.A., who reported on his participation in the Annual Safety Seminar of the Flight Safety Foundation held in Bermuda. Mr. Gough discussed many of the problems and latest developments in the fields of air-sea rescue, blind landing and approach, runway lighting, ditching, cockpit field of view, and fire control. He emphasized the need for adequate safety training and education and illustrated the general need for improved safety consciousness by relating in detail the causes and results of accidents that could have been prevented or reduced in severity by better trained

personnel. Mr. Gough also related in an interesting and amusing manner some of his personal experiences during his stay in Bermuda.

## Montreal Section

H. V. Braceland, *Secretary*

Chairman E. Schaefer opened the November 21 meeting by briefly summarizing the future activities of the Montreal Section. It was stated that it was intended to have a field trip in the near future, possibly to the McGill University jet research laboratory at St. Annes, Quebec. He then introduced the guest speaker, W. F. Milliken, Jr., of Cornell Aeronautical Laboratory, who is well known for his research work in dynamic stability and control.

Mr. Milliken originally presented this particular paper at the Third International Conference of the R.Ae.S. and I.A.S. in September, 1951. It was immediately evident that Mr. Milliken's research progress has covered many aspects of dynamic stability theory. He stated that original work was done almost entirely at subsonic speeds; however, in recent years transonic and supersonic test work was well under way at Cornell.

The speaker used many slides showing graphs of theoretical calculated and flight-test data which were results of development methods for obtaining the responses of full-scale aircraft to control forcing functions. Generally, the purpose of the entire time expended was to predict the behavior of existing aircraft with various types of automatic control, and, second, to check design dynamic characteristics both theoretical and in flight. As a result of this recent work, it is the policy of the American Air Force to perform routine dynamic response measurements during all prototype acceptance flight tests

The speaker envisioned aircraft of the future with such automatic dynamic control systems that almost any dynamic characteristic could be given to the aircraft. A lively discussion period followed.

A colored film that depicted the installation and flight characteristics of an automatic control system in operation during a stall glide in a PT-26 low-wing trainer followed Mr. Milliken's paper.

## Philadelphia Section

Emily Rogers, *Secretary*

On December 5, the Philadelphia Section of the I.A.S. held a joint meeting with the Philadelphia Section of the S.A.E. at the Engineers' Club. At this meeting, F. B. Lary, Project Engineer on Turbine Installations, Wright Aeronautical Division of Curtiss-Wright Corporation, gave a paper on "Installation Problems of the Turbo Jet."

In his interesting paper, Mr. Lary dealt with the oil cooling problem, among others. In this regard, he said: "Oil cooling at the high total temperatures associated with high airplane Mach Numbers, in most cases, is simplified by the ability to cool the oil with fuel. This generally eliminates the complicated oil air cooler and control."

Fuel system problems, Mr. Lary stated, are reduced by two factors—namely, the lack of sensitivity of the engines to vapor in fuel and the practice of keeping the fuel under pressure from the tank right to the burner. The problem of air-induction system, he said, is largely one of aerodynamics intimately connected with the airplane design. The same is true of the exhaust system, which demands great ingenuity in the cooling of the air ejector at the nozzle. Mr. Lary used the J-65 Sapphire turbojet engine for illustration purposes and as the basis for detailed analysis.

The problem of engine configuration and accessory arrangement is one that is without complete solution. This problem is becoming more complex


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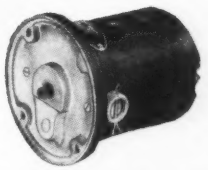

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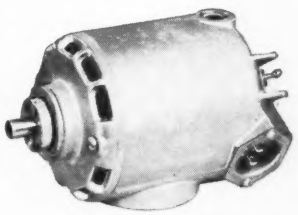

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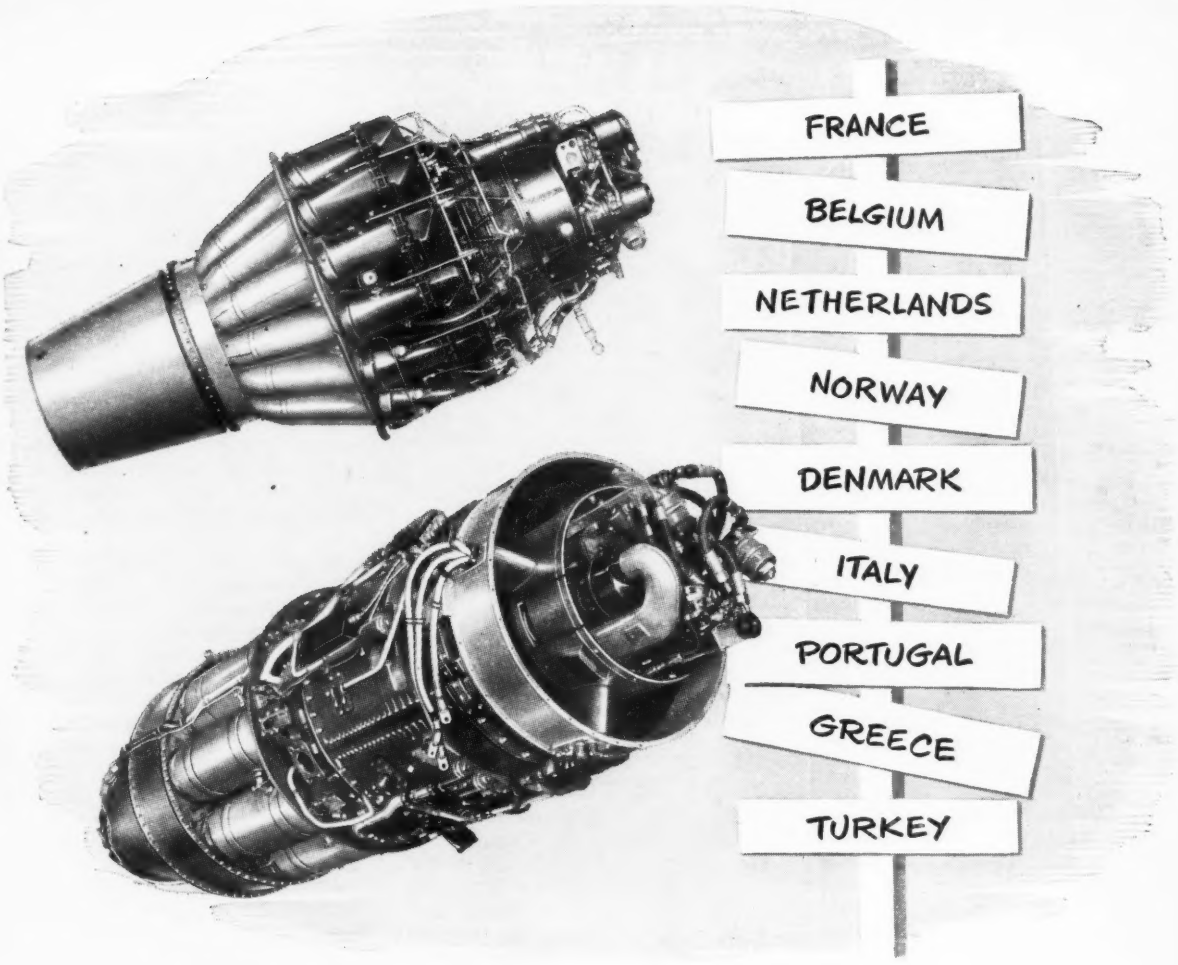
as the requirements for generators and hydraulic pumps become more severe and larger units are required. Also, the problems of engine controls, fuel systems, and electrical units, Mr. Lary continued, are becoming more acute as these units become more complex. If each engine and accessory system were tailored to suit the individual aircraft design in which it was to be used, a more ideal design situation would evolve. However, as a practical matter, it is necessary to design the engine to handle the worst requirement for each of the accessory units. The engine starter requirements also vary from one installation to another.

Some idea of the complexity of the accessory-drive problem will be had, Mr. Lary said, when it is realized that in one aircraft design two generators and one hydraulic pump may be required, while in another installation of the same engine one generator and two hydraulic pumps are needed. A generator drive requires twice the speed of the hydraulic pump, thereby adding to the complexity of the problem involved in connection with just these two accessories. In the final arrangement of the Sapphire J-65 engine, it is capable of driving a representative group of accessories required by all of the airplanes in which it is used. While the final arrangement offers only the near ideal for one or two airplane models in which the engine is used, it nevertheless provides a practical arrangement suitable for reasonable production handling. The production arrangement is arrived at, however, only through early development of the engine in which the accessory arrangements are retained in a more flexible form.

The cooling problem is complicated by the great variation in speed and the variation in pressure due to the great difference involved in altitude operation. Cooling of accessories, particularly those which have internal-heat generation, becomes acute. In many instances, a change of material is indicated, such as the use of silicon in place of rubber to provide resistance to higher temperatures.

Since the rotating parts of the engine are carefully balanced, the turbojet engine is smooth. Therefore, the problem of suspension and vibration can be handled in a relatively simple manner. The engine is supported at two points near the center of gravity and at a third point near one end in a fashion that will allow for expansion requirements. Vibration due to air-speed excitations in the duct system are sometimes troublesome. The pilot, of course, must be insulated from the effects from any of these high-frequency vibrations.

To come to grips effectively with these installation problems, said Mr. Lary, it is necessary that the engine people

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know the requirements of the airplane and that the accessory people know the conditions under which the accessories are to be used. Many of the elusive problems, such as vibration in the airplane, must be approached with complete cooperation by all concerned.

### St. Louis Section

Robert A. Killoren, *Secretary*

The December 11 meeting was held jointly with the American Helicopter Society because of mutual interest involved in the speaker's presentation. Fifty members attended. Chairman C. J. Wenzinger opened the meeting and presented the names of the St. Louis Section Representative and Program, Membership, and Nominating committees for the coming year.

Section Representative to the Nominating Committee for Aero Counselors is Norton B. Moore. The committee chairmen are: Program, Darrel B. Parke; Membership, Charles H. Marshall; and Nominating, David S. Lewis, Jr.

Charles R. Wood, Jr., introduced the speaker of the evening, Lt. Col. David E. Condon of the Air Training Department at Fort Sill, Okla. Colonel Condon's talk, "Helicopter Maintenance and Future Requirements," was based upon two years of experience in the actual operation and maintenance of rotary-wing aircraft.

Drawing upon data accumulated over these years, he presented an informative and interesting picture of the difficulties encountered in operating present-day helicopters. The lack of replacement parts and the large proportion of maintenance hours to flight hours were enumerated as major difficulties.

Several points were discussed for improvement in design, especially from a maintenance angle.

The formal portion of the discussion was followed by numerous questions which showed the great interest aroused by his discussion.

## Student Branches

### Brown University

On December 7, 12 members were present to hear Gordon Anderson, Instructor and Research Associate at Brown, deliver a lecture on "Problems in the Design of a Dehumidifier." Chairman Rodger Dowdell presided.

### Clarkson College of Technology

Chairman William C. Martin presided at the December 5 meeting at which 46 students were present. Two films, *British Aircraft Review* and *Silverstone Grand Prix*, were shown.

### University of Notre Dame

Chairman Peter Skerret presided at the December 13 meeting at which 17 persons were present. The speaker was Edward Gohman, Vice-Chairman of the Notre Dame student branch, who spoke on "The Drag Alleviation Effects of Delta Wings." A film, *Aerodynamics Drag*, was shown.

### The Ohio State University

Chairman Richard G. Docken led the December 5 meeting at which Al Funkhouser, Head, Field Service Correspondence Department, Columbus Division, North American Aviation, Inc., spoke on "Field Service Correspondence." Twelve persons were present.

### The Pennsylvania State College

Three films were shown to the 35 attending students on December 6. The pictures were: *Operation of Jet Aircraft Engines*, *History of Guided Missiles*, and *Takeoff of Carrier Aircraft*. Chairman George Page presided.

On December 13, a dinner meeting was held. Toastmaster Earl Uram introduced the speaker, Charles Speidel, Head Wrestling Coach at Penn State, who spoke on his war experiences in the Far East.

### Purdue University

On November 28, 50 persons heard A. L. Morse, Engineer, Technical Development and Evaluation Center, Civil Aeronautics Administration, present a lecture on "Crash Resistant Fuel Tanks." Chairman Paul Kesling, Jr., presided.

### Rensselaer Polytechnic Institute

Dr. Paul Lieber, Associate Professor of Aeronautical Engineering, R.P.I., spoke at the November 14 meeting on the subject, "Basic Theory of Aerodynamics." A film from the British Information Service, *Faster than Sound*, was shown. Chairman Jack E. Williams presided; 40 persons were present.

On December 12, Prof. A. J. Fairbanks, Associate Head, Aeronautical Engineering Department, R.P.I., introduced William Stieglitz, Design Safety Engineer, Republic Aviation Corporation, and R. W. Woodham, Administrator, Guggenheim Aviation Safety Center, who spoke on Aviation Safety. A British film, *Farnborough—1950*, concluded the meeting at which Chairman Williams presided and 40 students were present.

### Syracuse University

At the December 5 meeting, a motion picture entitled *D. Z. Normandie* was shown. Chairman Jack Andrews presided; 11 members were present

### The University of Texas

On November 5, Chairman Gerald W. Walker introduced the speaker, W. H. Shutts, Instructor in the Department of Aeronautical Engineering, who spoke on the I.A.S. A film, *Guided Missiles*, was shown to the 45 students who were present.

On December 6, 15 persons heard a lecture delivered by H. J. McNeel, Armament Engineer, North American Aviation, Inc., Mr. McNeel's topic was "The Organization of a North American Plant." Chairman Walker presided.

### University of Toronto

Fred Buller, Chief Design Engineer, de Havilland Aircraft of Canada, Ltd., addressed an audience of 23 persons on the subject of "Design: Theory vs. Practicability." A film on the design, construction, and testing of the de Havilland Beaver was shown. Chairman J. E. Topping presided.

### Tri-State College

On December 6, O. E. Wells, a graduate of Tri-State who is now Chief Structures Engineer, Cessna Aircraft Company, spoke to the 39 attending students on "Preliminary Airplane Design and What the Graduate Engineer Can Expect in Industry." The banquet meeting was concluded by the awarding of certificates and the announcement of officers for the spring term. Certificates were given to the following members: Chairman, John Accashian; Vice-Chairman, Hilliard Price; Secretary, Wayne Peck; and Treasurer, Orison Turner. The incoming officers are: Chairman, Jack Jewel; Vice-Chairman, Wayne Peck; Secretary, William Wade; and Treasurer, Louis O'Brocta. Chairman John Accashian presided.

### West Virginia University

On November 7, two films, *Jap Zero* and *Winning Your Wings*, were shown to the 15 attending students. Chairman Eugene Fourney presided.

A film, *The Story of the Flying Wing*, was shown at the December 5 meeting at which 16 persons were present and Chairman Fourney presided.

## Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

### Elected to Associate Fellow Grade

**Dehmel, Richard C.,** Ph.D., Chief Engineer, Electronic Div., Curtiss-Wright Corp.

**Pearson, J. B., Jr.,** M.S., Rear Admiral, U.S.N.; Dir., Industrial Surveys, Officer of the Naval Insp. Gen., Office of the Chief of Naval Operations, Dept. of the Navy (Washington, D.C.).

### Transferred to Associate Fellow Grade

**Beard, Myron G.,** B.E., Chief Engineer, American Airlines, Inc.

**Bisplinghoff, Raymond L.,** S.M., Associate Prof. of Aero. Engineering, Massachusetts Institute of Technology.

**Goland, Martin,** M.M.E., Associate Director for Engineering, Midwest Research Institute; Editor, *Applied Mechanics Reviews.*

**Merrill, Grayson,** B.S., Comdr., U.S.N.; Plans Officer, Guided Missiles Div., Bureau of Aeronautics, Dept. of the Navy.

**Thurston, David B.,** B. of Ae.E., Chief Engineer, Brown & Mole, Inc.

### Elected to MEMBER Grade

**Arnoldi, Robert A.,** M.S. Applied Math., Analytical Engineer, Research Dept., United Aircraft Corp.

**Baltensweiler, A. O.,** Dipl. Ing., Chief Engineer, SwissAir Transport Co.

**Bell, William D.,** Vice-President in Charge of Computing Div., Telecomputing Corp.

**Bogema, Bernard L.,** B. of Ae.E., Group Engineer—Structures, The Glenn L. Martin Co.

**Crites, Sherman E.,** M. of Ae.E., Tech. Engineer, Project Objectives Div., Aircraft Gas Turbine Dept., General Electric Co.

**Durham, Franklin P.,** M.S.M.E., Asst. Prof. of Aero. Engineering; Project Dir., Engineering Experiment Station, University of Colorado.

**Erickson, B. A.,** Chief Test Pilot & Mgr. of Flight Dept., Consolidated Vultee Aircraft Corp.

**Everingham, Lloyd R.,** B.S., Asst. to Dir., Cornell Aero. Lab., Inc.

**Holden, William H. T.,** B. A., Consultant, Gaveco Labs., Inc.; Bowser, Inc.; General Aviation Equipment Co.

**Kaye, Joseph,** Ph.D., Assoc. Prof. of Mechanical Engineering, Massachusetts Institute of Technology.

**Kotowski, Richard J.,** Designer, Aircraft Div., Kaiser Metal Products (Bristol, Pa.).

**Kuhl, John Ernest,** B.S. in Ae.E., Engineering Designer, North American Aviation Inc.


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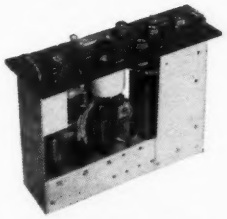

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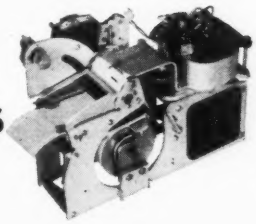

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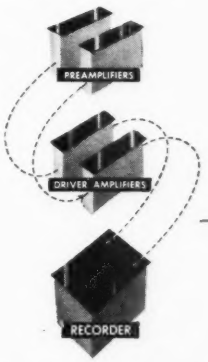


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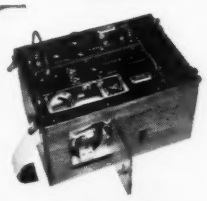

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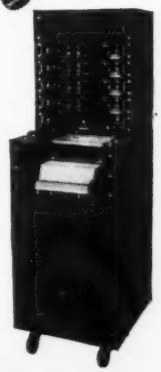

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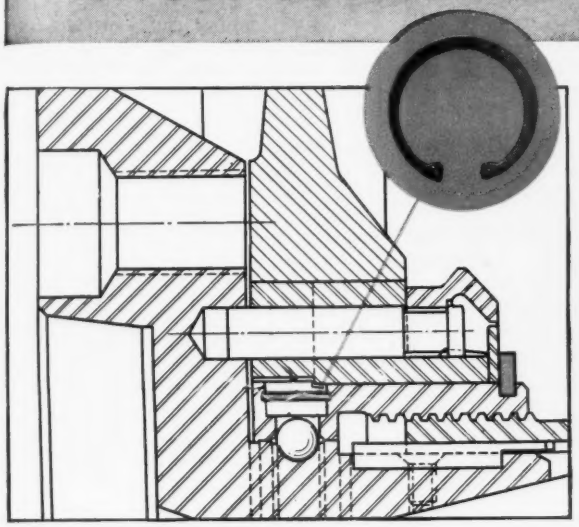

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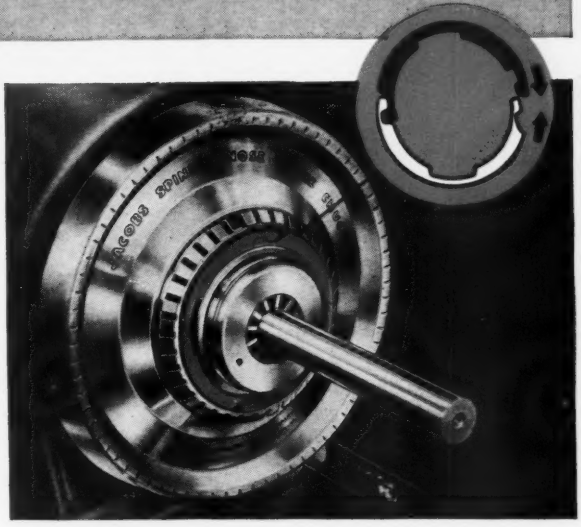

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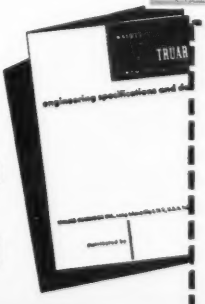

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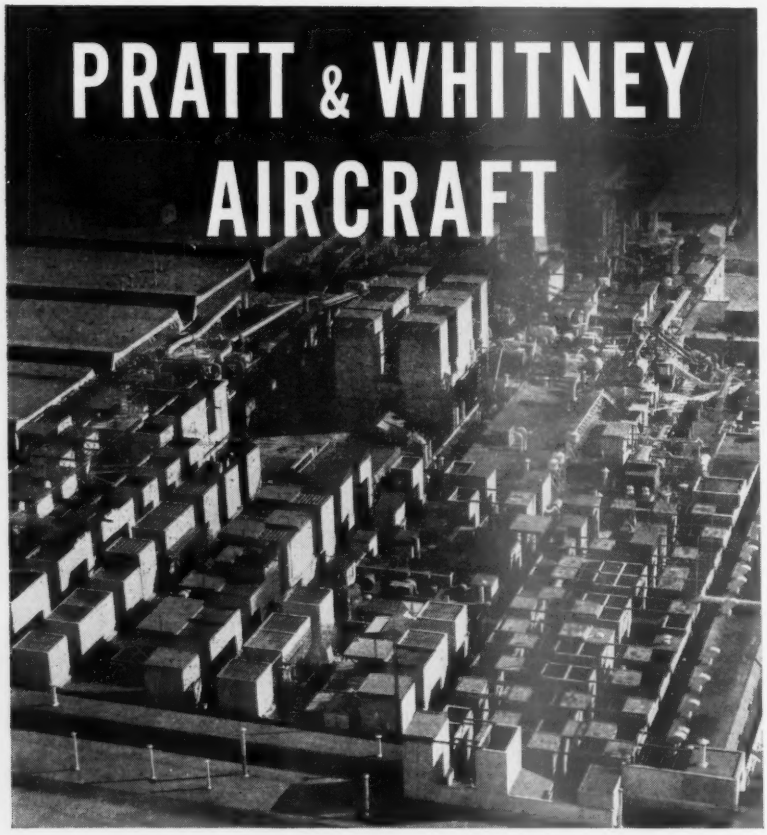


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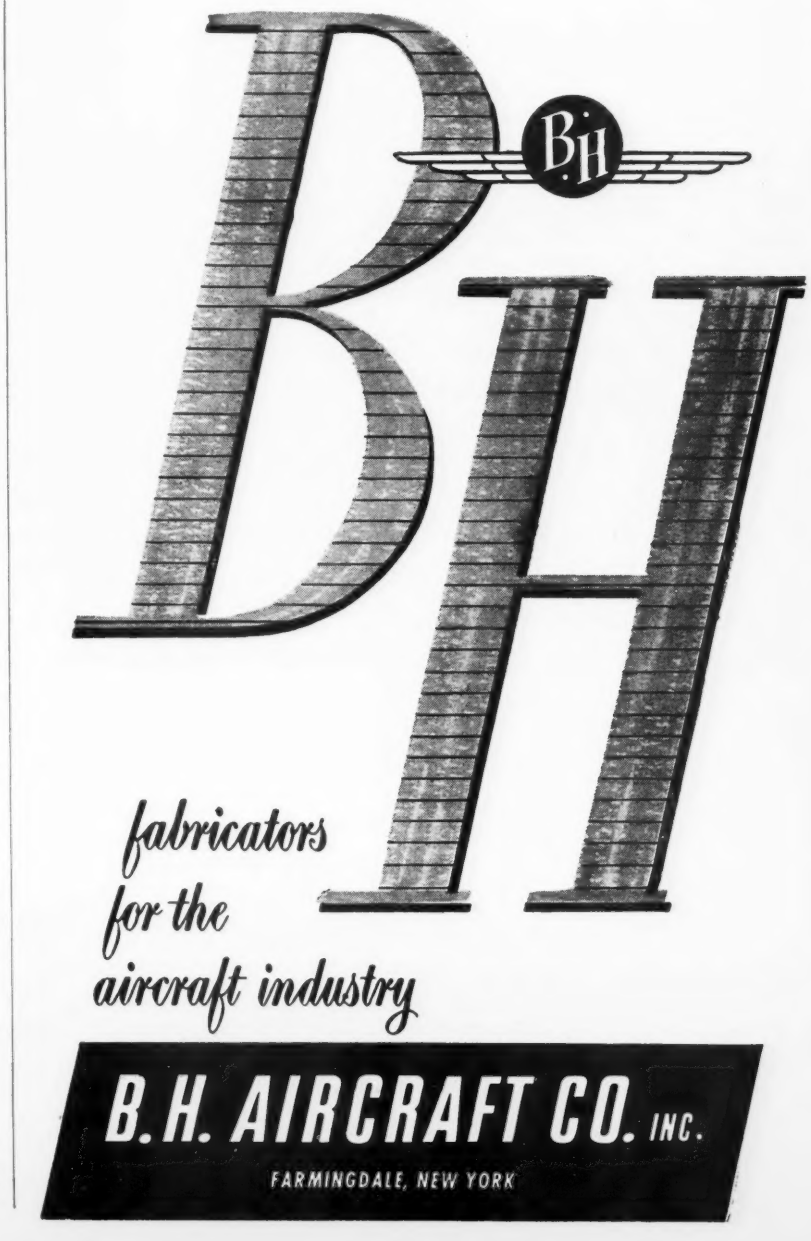

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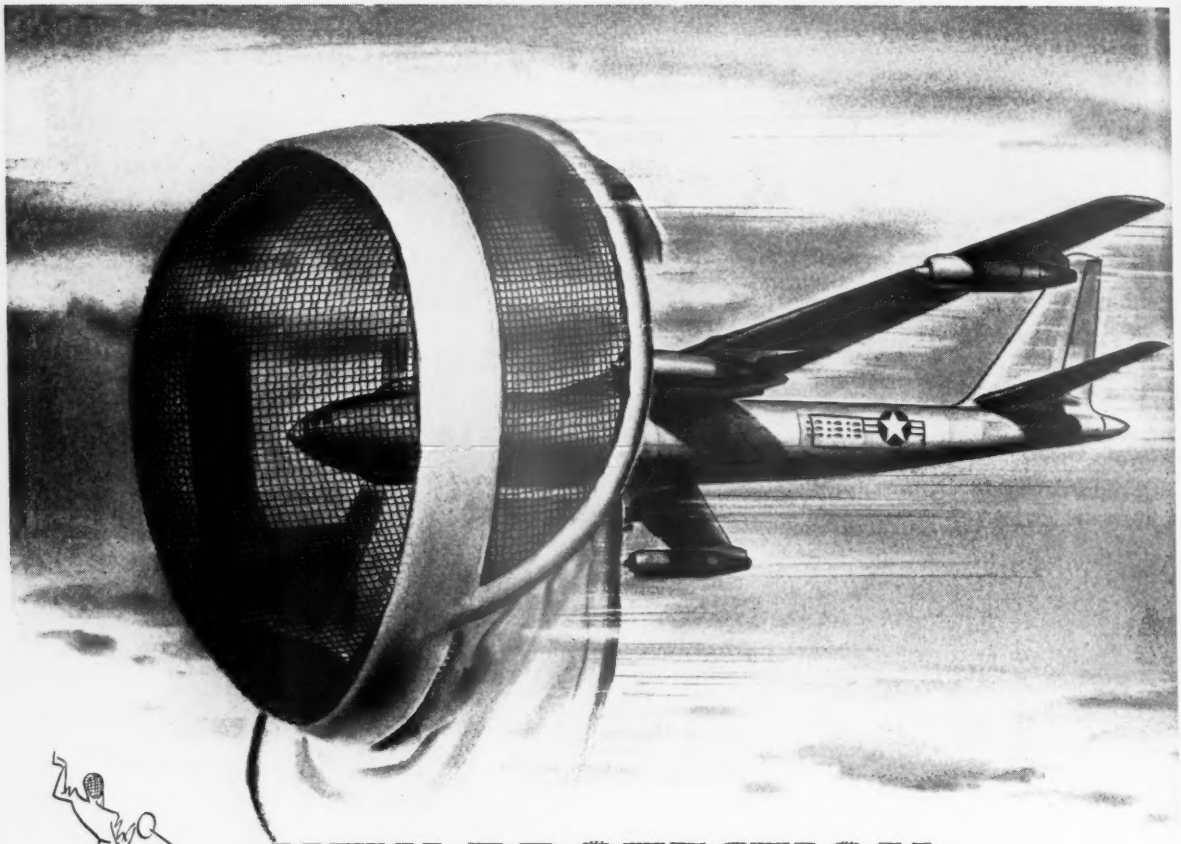

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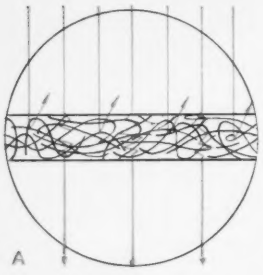


Diagrammatic enlargement of cross section of paper with high strength but low transparency. Fibers are surrounded by air, which has different index of refraction. Many light rays are bent back and do not get through.

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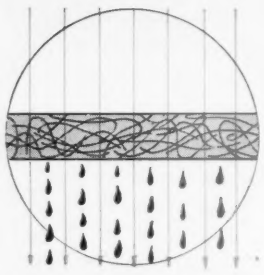

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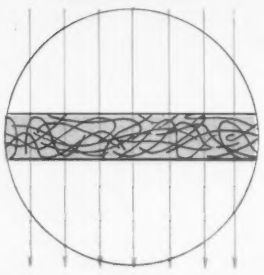

Same paper as "A", filled with an inert synthetic resin, with correct index of refraction. This is how Albanene is made. Its transparentizer does not "bleed" out. Albanene holds its color and strength and is permanently transparent.†

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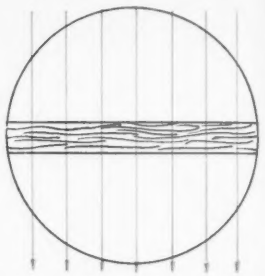

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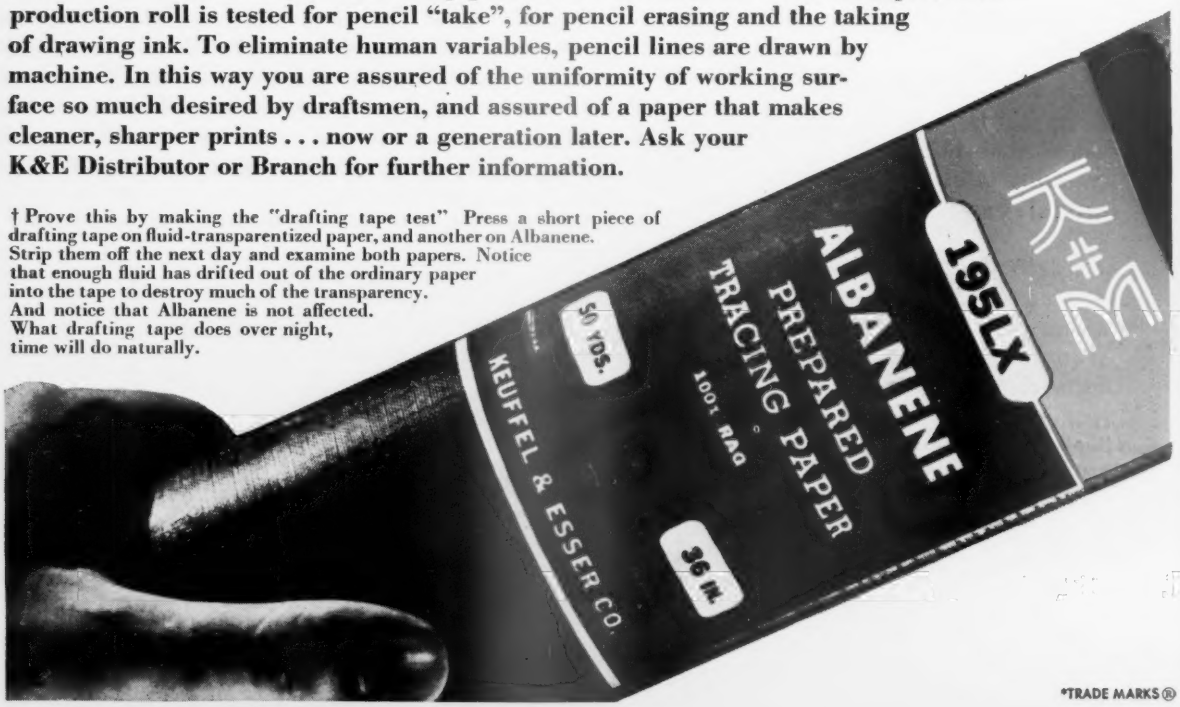


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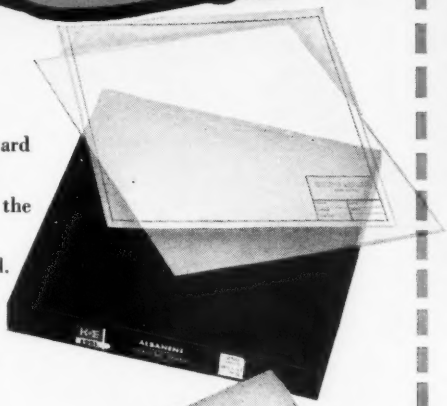

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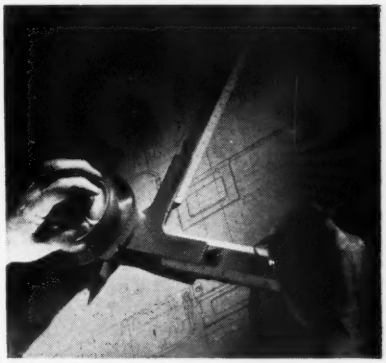

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## Aerodynamics (2)

**Some Aerodynamic Problems in Supersonic Design.** H. O. Palme. *Saab Sonics*, No. 15, July–September, 1951, pp. 14–17, 24, illus. Aerodynamic design factors in the development of fighter aircraft for speeds up to $M = 1.5$.

### BOUNDARY LAYER & THERMOAERODYNAMICS

**On Motion of Fluid in Boundary Layer Near Line of Intersection of Two Planes.** L. G. Loitsianskii and V. P. Bolshakov. (*Moscow, Tsentral'nyi Aero-Gidrodinamicheskii Institut, Trudy*, No. 279, 1936.) *U.S., N.A.C.A., Technical Memorandum No. 1308*, November, 1951. 27 pp., illus. 1 reference.

Formulation of the problem of the interaction of the boundary layers near the intersection of a dihedral angle of from 0° to 180°; solution by the von Kármán-Pohlausen method; analysis of the interference limits and of the drag correction due to the interference effect.

**Readers' Forum: On the Stability of the Boundary Layer with Respect to Disturbance of Large Wave Velocity.** C. C. Lin. *Journal of the Aeronautical Sciences*, Vol. 19, No. 2, February, 1952, pp. 138, 139. 6 references.

**Boundary Layer Control.** *Aero Digest*, Vol. 63, No. 5, November, 1951, pp. 22–25, illus.

Boundary-layer control tests with suction through porous metal on the leading edge of an aircraft in flight; possible application of leading-edge suction to high-speed turboprop, turbojet, and rocket aircraft; advantages of porous metal when substituted for slots to admit air.

**Heat Transfer by Laminar Flow from a Rotating Plate.** Knox Millsaps and Karl Pohlhausen. *Journal of the Aeronautical Sciences*, Vol. 19, No. 2, February, 1952, pp. 120–126, illus. 8 references. Exact solution of the heat-transfer problem for the von Kármán example of the laminar flow of a viscous fluid over a rotating plate.

**Table of the Integral $\int_0^x e^{-u^3}\,du$.** Milton Abramowitz. *Journal of Mathematics and Physics*, Vol. 30, No. 3, October, 1951, pp. 162, 163. 1 reference. This function occurs in the solution of the equation for heat conduction for a fluid flowing past a flat plate.

**An Experimental Investigation of the Isothermal Laminar Boundary Layer on a Porous Flat Plate.** Paul A. Libby, Lawrence Kaufman, and R. Paul Harrington. *Journal of the Aeronautical Sciences*, Vol. 19, No. 2, February, 1952, pp. 127–134, illus. 20 references.

Experimental apparatus, techniques, and data on the laminar isothermal boundary-layer characteristics on a porous flat plate with suction or injection of the same fluid as the main stream; comparison with values predicted by boundary-layer theory.

**Contribution to the Calculation of Turbulent Boundary Layers.** J. Rotta. (*Max-Planck-Institut für Stromüngsforschung, Göttingen, Mitteilung*, July, 1950.) *U.S., Navy Department, David W. Taylor Model Basin, Translation No. 242*, November, 1951. 20 pp., illus. 16 references.

Development of an approximate method of calculation of turbulent boundary layers, based on the integral theorems for momentum and energy balance and the empirical relations between the quantities as obtained from an evaluation of test data; comparison with other approximate calculation procedures.

### FLUID MECHANICS & AERODYNAMIC THEORY

**An Introduction to the General Equations of Fluid Dynamics.** G. N. Patterson. *Toronto, University, Institute of Aerophysics, Review No. 3*, December, 1950. 73 pp., illus. 1 reference.

**Fluid Dynamics.** Max Leva and Murray Weintraub. *Industrial and Engineering Chemistry*, Vol. 43, No. 1, January, 1951, pp. 90–99. 344 references. Review of the literature from October, 1949, to September, 1950, covering most phases of fluid dynamics.

**Viscosity Behavior of Gases.** I. A. Bromley and C. R. Wilke. *Industrial and Engineering Chemistry*, Vol. 43, No. 7, July, 1951, pp. 1641–1648, illus. 16 references.

Charts and simplified equations for the estimation of the effects of temperature at low pressures, and of pressure and temperature at high pressures; constants for the gas mixture-viscosity equations.

**Starting Processes in an Intermittent Supersonic Wind Tunnel.** G. V. Bull. *Toronto, University, Institute of Aerophysics, Report No. 12*, February, 1951. 48 pp., illus. 9 references.

Theoretical and experimental analyses of the nonstationary and quasi-steady flow phenomena associated with the setting up of a gradient-free supersonic air stream in an intermittent-type wind tunnel.

**The Linearized Characteristics Method and Its Application to Practical Nonlinear Supersonic Problems.** Antonio Ferri. *U.S., N.A.C.A., Technical Note No. 2515*, October, 1951. 65 pp., illus. 6 references.

**Shatter of Drops in Streams of Air.** W. R. Lane. *Industrial and Engineering Chemistry*, Vol. 43, No. 6, June, 1951, pp. 1312–1317, illus. 13 references. Results of a study of the degree of atomization of drops in steady and transient air streams at sonic and supersonic velocities.

**The Behavior at Infinity of the Potential Function of a Two-Dimensional Subsonic Compressible Flow.** G. S. S. Ludford. *Journal of Mathematics and Physics*, Vol. 30, No. 3, October, 1951, pp. 117–130, 6 references.

Analysis of the flow resulting from the disturbance of a uniform compressible stream by a system of bodies subject to surface suction. The flow is assumed to be inviscid, irrotational, steady, and free from turbulence.

**Readers' Forum: A Method of Solving the Linear Potential Equation for Axially Symmetric Flow.** R. Probstein and J. V. Charyk. *Journal of the Aeronautical Sciences*, Vol. 19, No. 2, February, 1952, pp. 139, 140, illus. 1 reference.

Calculation of the pressure distribution over a body of revolution at zero angle of attack by a method that does not involve separating the body into a series of conical flow sections; applicability of the method.

**Minimum Wave Drag of Bodies of Revolution with a Cylindrical Center Section.** Franklyn B. Fuller and Benjamin R. Briggs. *U.S., N.A.C.A., Technical Note No. 2535*, October, 1951. 34 pp., illus. 9 references.

Solution of the minimum wave-drag problem for the axial flow about bodies of revolution that consist of two symmetric ogival sections joined by a circular cylinder, assuming constant values for the total body length, cylinder length, frontal area, and volume.

**Supersonic Flow Around Cones at Large Yaw.** G. B. W. Young and C. P. Siska. *Journal of the Aeronautical Sciences*, Vol. 19, No. 2, February, 1952, pp. 111–119, 142, illus. 9 references.

Development of equations for the flow properties in the region bounded by a supersonic cone body at large angle of attack and its attached shock wave for use with the tabulations of Kopal.

**Circular Cylinder and Flat Plate Airfoil in a Flow Field with a Parabolic Velocity Distribution.** H. T. Nagamatsu. *Journal of Mathematics and Physics*, Vol. 30, No. 3, October, 1951, pp. 131–139, illus. 4 references.

Free-stream analysis of the incompressible, steady, nonviscous, two-dimensional flow over a circular cylinder with and without circulation in a parabolic velocity distribution; effects of parabolic and linear velocity distributions over a flat plate at various angles of attack.

**Air Drag on Cubes at Mach Numbers 0.5 to 3.5.** George E. Hansche and John S. Rinehart. *Journal of the Aeronautical Sciences*, Vol. 19, No. 2, February, 1952, pp. 83, 84, illus. 1 reference.

**A Study of Supersonic Flows in a Shock Tube.** R. K. Lobb. *Toronto, University, Institute of Aerophysics, Report No. 8*, May, 1950. 62 pp., illus. 7 references. Analysis of the theoretical and experimental aspects of the one- and two-dimensional simple wave phenomena produced in a shock tube.

**First and Second Approximations for the Solution of Flows with Curved Shocks.** Bernard Etkin. *Toronto, University, Institute of Aerophysics, Report No. 13*, February, 1948. 20 pp., illus. 3 references.

Solution by first-order methods for unsteady one-dimensional and steady two-dimensional flows containing curved shock waves. A step-by-step solution of the shock is obtained by using the characteristic equations of the flow and the jump conditions at the shock.

**On Unsteady Nonlinearized Conical Flow.** S. F. Borg. *Journal of the Aeronautical Sciences*, Vol. 19, No. 2, February, 1952, pp. 85–92, 100, illus. 21 references. Analysis of the conical form of the equations for the unsteady, nonlinear, nonviscous, nonheat-conducting flow for the case of a shock striking an infinite wedge.

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**Experiments on the Amplification of a Plane Shock Wave.** D. Bitondo. *Toronto, University, Institute of Aerophysics, Report No. 7*, June, 1950. 55 pp., illus. 3 references.

Review of the theory of wave amplification and experimental verification of the theory. A shock-tube technique was developed in which microfilm was used to separate gas combinations of air-carbon dioxide and air-argon at the contact surface; the resulting wave velocities were extrapolated to zero thickness and converted to pressure ratios for comparison with theoretical values.

**One-Dimensional Theory of Absorption and Amplification of a Plane Shock Wave by a Gaseous Layer.** D. Bitondo, I. I. Glass, and G. N. Patterson. *Toronto, University, Institute of Aerophysics, Report No. 5*, June, 1950. 63 pp., illus. 7 references.

Analysis of the problem of the gaseous refraction of a plane shock wave at a contact surface. Two types of interaction are considered: the case where the reflected wave is a rarefaction wave and the transmitted shock wave is of lower strength than the incident wave; and the case where the reflected wave is a shock wave and the transmitted shock wave is of higher strength than the incident wave.

**Refraction of a Shock Wave of a Gaseous Interface.** D. H. Henshaw. *Toronto, University, Institute of Aerophysics, Report No. 11*, October, 1950. 15 pp., illus. 4 references.

Theoretical study of the two-dimensional, steady, supersonic flow and in two adjacent uniform streams of polytropic gas, using a stepwise procedure involving both graphic and analytic methods; experimental study at a high Mach Number using a nozzle arrangement.

**Transition Through a Weak Shock Front.** G. N. Patterson. *Toronto, University, Institute of Aerophysics, Report No. 1*, May, 1948. 24 pp., illus. 4 references.

Solution of the problem of the transition of velocity through a weak shock front, based on the general equations of motion of a continuous fluid, and assuming that the coefficients of viscosity and heat conduction remain constant.

**Application of Variational Methods to Transonic Flows with Shock Waves.** Chi-Teh Wang and Pei-Chi Chou. *U.S., N.A.C.A., Technical Note No. 2539*, November, 1951. 32 pp., illus. 11 references.

**On the Spectrum of Isotropic Turbulence.** H. W. Liepmann, J. Laufer, and Kate Liepmann. *U.S., N.A.C.A., Technical Note No. 2473*, November, 1951. 61 pp., illus. 26 references.

Measurements of the spectrum and correlation functions at large Reynolds Number ($RN \approx 10^5$ based on the grid mesh), and a series of accurate spectrum measurements at lower Reynolds Number ($RN \approx 10^4$). The results are compared with the theoretical laws proposed in recent years.

## INTERNAL FLOW

**Readers' Forum: Note About Secondary Flow in Cascades.** Hans P. Eichenberger. *Journal of the Aeronautical Sciences*, Vol. 19, No. 2, February, 1952, pp. 137, 138, illus. 3 references. Calculation of trailing vorticity behind a cascade of airfoils in shear flow; physical reality of Stephenson's method.

**Analysis of an Axial Compressor Stage with Infinitesimal and Finite Blade Spacing.** H. J. Reissner and L. Meyerhoff. *U.S., N.A.C.A., Technical Note No. 2493*, October, 1951. 31 pp., illus. 2 references. Development of a method of designing circular blade systems of finite spacing.

**Measurement of Instantaneous Vector Air Velocity by Hot-Wire Methods.** Carl E. Pearson. *Journal of the Aeronautical Sciences*, Vol. 19, No. 2, February, 1952, pp. 73–82, illus. Theory, construction, and use of a hot-wire probe for obtaining the average and instantaneous vector velocity of airflow behind the impeller of a compressor.

**Contributions to the Theory of the Spreading of a Free Jet Issuing from a Nozzle.** W. Szablewski. (*Untersuchungen und Mitteilungen Nr. 8003*, September, 1944.) *U.S., N.A.C.A., Technical Memorandum No. 1311*, November, 1951. 72 pp., illus. 6 references.

For the flow field of a free jet leaving a nozzle of circular cross section in a medium with straight uniform flow field, approximate formulas are presented for the calculation of the velocity distribution and the dimensions of the core region.

**Some Remarks on the Coupling of Two Ducts.** Albert E. Heins. *Journal of Mathematics and Physics*, Vol. 30, No. 3, October, 1951, pp. 164–169. 4 references. Formulation of the problem; selection of the appropriate Green's function.

**Readers' Forum: A Note on the Design of Supersonic Wind-Tunnel Nozzles.** R. E. Meyer. *Journal of the Aeronautical Sciences*, Vol. 19, No. 2, February, 1952, pp. 140, 141. 3 references.

**Readers' Forum: Effect of Wind-Tunnel Nozzle on Steady-Flow Nonuniformities.** Stanley Corrsin. *Journal of the Aeronautical Sciences*, Vol. 19, No. 2, February, 1952, pp. 135–136. 1 reference.

Analysis of the effect of upstream density irregularities on the working section velocity irregularities in a low-speed tunnel; extension to compressible flow of Prandtl's estimate for the effect of upstream irregularities in mean velocity and stagnation temperature.

**Critical Pressures for the Inception of Cavitation in a Large-Scale Numachi Nozzle As Influenced by the Air Content of the Water.** S. F. Crump. *U.S., Navy Department, David W. Taylor Model Basin, Report No. 770*, July, 1951. 18 pp., illus. 12 references. Comparison of critical pressure data obtained in a 12-scale model of a Numachi Nozzle 22, a venturi-type nozzle with an abrupt diffuser, with Numachi's data.

## NATURAL FLIGHT

**Some Thoughts on Natural Flight.** James L. G. FitzPatrick. *Technology Review*, Vol. 54, No. 1, November, 1951, pp. 21–28, 42, 44, illus. Theories of bird and insect flight and their possibilities for aircraft design.

**Dynamic Soaring.** Heinz Kensche. (*Thermik*, January-February, 1951.) *Sailplane and Glider*, Vol. 19, No. 11, November, 1951, pp. 249, 250, 260, 261, illus. Observations on soaring in which attempts are made to draw energy from the atmosphere (use of wind gradients for flight), as shown by the flying habits of the albatross.

**Flying-Fish Aerodynamics.** C. H. Latimer-Needham. *Flight*, Vol. 60, No. 2231, October 26, 1951, pp. 535, 536, illus. Analysis of theories concerning, and the method of, flight employed by flying fish.

## PERFORMANCE

**The Effect of Rate of Change of Angle of Attack on the Maximum Lift Coefficient of a Pursuit Airplane.** Burnett L. Gadeberg. (*U.S., N.A.C.A., Research Memorandum No. A8I30*, 1948.) *U.S., N.A.C.A., Technical Note No. 2525*, October, 1951. 17 pp., illus. 3 references.

## WINGS & AIRFOILS

**Readers' Forum: On Nonplanar Surfaces of Very Low Aspect Ratio.** H. M. Voss. *Journal of the Aeronautical Sciences*, Vol. 19, No. 2, February, 1952, pp. 136–137, illus. 11 references. Analysis of the behavior of a nonplanar surface in steady flow and arbitrary unsteady motion, based on the fact that the deflection and the downwash are developable in a finite Fourier series in $y/S(x)$.

**Investigations on Wings with and Without Sweepback at High Subsonic Speeds.** Jakob Ackeret, Max Degen, and Nikolaus Rott. (*Zeitschrift für Angewandte Mathematik und Physik*, Vol. 1, 1950.) *U.S., N.A.C.A., Technical Memorandum No. 1320*, November, 1951. 14 pp., illus. 4 references.

Drag tests at zero lift at Mach Numbers from 0.7 to approximately 0.95 in the high-speed wind tunnel of the Institut für Aerodynamik, Eidgenössische Technische Hoschschule, Zurich, on untapered wings of aspect ratio 3.25, sweepback angles 0° and 35°, and thickness ratios of 9 and 12 per cent. Tests of geometrically similar models at a constant Reynolds Number provided a verification of computed tunnel blocking corrections. Test data were compared with values predicted from von Kármán's similarity law.

**Readers' Forum: On Slender Wing-Body Theory.** John W. Miles. *Journal of the Aeronautical Sciences*, Vol. 19, No. 2, February, 1952, p. 140. 3 references. Remarks on the inaccuracies in Spreiter's analysis of the slender wing-body problem.

**Readers' Forum: On Chang's Function for Nonstationary Flow.** John W. Miles. *Journal of the Aeronautical Sciences*, Vol. 19, No. 2, February, 1952, p. 138. 2 references. Note on the solution of an equation from Chang's work on nonstationary airfoil theory.

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## Aeroelasticity

**Influence of Static Longitudinal Stability on the Behavior of Airplanes in Gusts.** H. Hoene. (*ZWB, Forschungsbericht Nr. 1422*, December 31, 1940.) *U.S., N.A.C.A., Technical Memorandum No. 1323*, November, 1951. 26 pp., illus. 7 references.

Analysis of how additional accelerations produced by three different standard gust forms vary in relation to changes in the position of the center of gravity and in static longitudinal stability, using models of the Henschel HS122 and Heinkel HE45; comparison of results with flight measurements.

**Experimental Aerodynamic Derivatives of a Sinusoidally Oscillating Airfoil in Two-Dimensional Flow.** Robert L. Halfman. *U.S., N.A.C.A., Technical Note No. 2465*, November, 1951. 83 pp., illus. 7 references.

Analysis of the lift and moment on a symmetric airfoil oscillating harmonically in a two-dimensional flow; comparison of results with the predictions of the vortex-sheet theory and with research data; application to the flutter problem. A survey of reference materials is given in the appendix.

**The Aerodynamic Forces on an Oscillating Aerofoil Between Two Parallel Walls.** R. Timman. *Applied Scientific Research, Section B, Electrophysics, Acoustics, Optics, Mathematical Methods*, Vol. A3, No. 1, 1951, pp. 31–57, illus. 6 references.

An exact solution for correcting for the influence of the walls in wind-tunnel experiments on an oscillating wing between two parallel walls. The solution is based upon Green's function expressed in elliptic functions.

**Theoretical Investigation of Several Types of Single Degree of Freedom Flutter.** Harry L. Runyan, Herbert J. Cunningham, and Charles E. Watkins. *Journal of the Aeronautical Sciences*, Vol. 19, No. 2, February, 1952, pp. 101–110, 126, illus. 17 references. Theoretically predicted effects of primary parameters associated with single degree of freedom flutter, considering both subsonic and supersonic cases.

**Ternary Wing Bending-Aileron-Tab Flutter.** A. I. van de Vooren and D. J. Hofsommer. *Netherlands, Nationaal Luchtvaartlaboratorium, Amsterdam, Report No. F.86*, May 4, 1951. 46 pp., illus., folding charts. 5 references.

Investigation of the flutter behavior of a two-dimensional wing-aileron-tab system for four boundary cases, neglecting the spring stiffness between the aileron and aileron lever. Results are presented as stability diagrams.

## Air Transportation (41)

**Airline Frequencies and Aircraft Design.** Garret Fitzgerald. *Shell Aviation News*, No. 160, October, 1951, pp. 14–17. Analysis of the problem of selecting aircraft with capacities adequate for the volume of traffic occurring on a given route at the optimum frequency.

**A Guide to Air Shipping Via the Port of New York.** *Port of New York Authority, Department of Aviation Development*, November, 1951. 28 pp., tables. Economics and mechanics of routing air cargo through the Port of New York from inland points; problems involved; tables of rates and specific shipping data.

## Airplane Design (10)

**Some Aerodynamic Problems in Supersonic Design.** H. O. Palme. *Saab Sonics*, No. 15, July–September, 1951, pp. 14–17, 24, illus. Aerodynamic design factors in the development of fighter aircraft for speeds up to M = 1.5.

### AIRPLANE DESCRIPTIONS

**Experimental Agricultural Aircraft.** *Shell Aviation News*, No. 160, October, 1951, pp. 18, 19, illus.

Performance and specifications of a prototype agricultural aircraft for spraying and dusting developed by the C.A.A., Department of Agriculture, Flying Farmers, and 13 aircraft manufacturers.

**Rocket Propelled Aircraft.** Kurt R. Stehling. *Engineering Journal*, Vol. 34, No. 10, October, 1951, pp. 975–979, illus. 5 references. Early applications of rocket propulsion to aircraft; design and performance of the Bell X-I and comparison with conventional planes and other rocket aircraft.

**Troop Carrier and Assault Aircraft.** Floyd J. Sweet. *SAE Journal*, Vol. 59, No. 11, November, 1951, pp. 25–27, illus. (Based on a paper.) Design requirements, from the tactical point of view, of troop-carrier and assault aircraft.

**Wings of Britain.** *Canadian Aviation*, Vol. 24, No. 11, November, 1951, pp. 23–77, illus. Review of British progress; military, civil, and research aircraft design.

**Novel French Aircraft.** William Green. *Ordnance*, Vol. 36, No. 189, November-December, 1951, pp. 394–397, illus. Design trends and special features of French research and military aircraft.

**Auster Aiglet Fully-Aerobatic Trainer Aircraft, England.** John Fricker. *The Aeroplane*, Vol. 81, No. 2100, October 19, 1951, pp. 528, 529, illus.

**de Havilland D.H. 114 Heron 14-Passenger Four-Engined Transport Airplane, England.** *de Havilland Gazette*, No. 65, October, 1951, pp. 124–126, illus. Direct operating costs of the de Havilland four-engined feeder liner based upon the standard method of calculation of the Society of British Aircraft Constructors.

**Douglas AD-5 Skyraider Fighter Aircraft.** *Aero Digest*, Vol. 63, No. 5, November, 1951, pp. 26–32, 34, 36, 38, 40, illus., cutaway drawing.

**Fletcher BT-22 Single-Engined Basic Trainer Aircraft (Aviation Design Progress).** Randolph Hawthorne. *Aviation Age*, Vol. 16, No. 5, November, 1951, pp. 40, 41, illus., cutaway drawing. The air frame of the Fletcher BT-22 trainer is designed to accommodate either a modified Wright R-1820-78 engine driving an Aeroproducts pusher-type propeller or a Westinghouse 24C-4B axial-flow turboprop power plant.

**Piaggio P-148 Single-Engined Two-Three-Place Trainer, Italy.** *The Aeroplane*, Vol. 81, No. 2102, November 2, 1951, pp. 586–588, illus.

### LANDING GEAR

**Undercarriage Manufacture.** *Aircraft Production*, Vol. 13, No. 157, November, 1951, pp. 350–355, illus. Production methods and tooling for the oleo-leg for Vickers-Supermarine Attacker.

### WING GROUP

**Martin 4-0-4 Automatic Trim.** Stanley A. Cook. *Aviation Age*, Vol. 16, No. 5, November, 1951, pp. 16–18, illus. Operation of the adjustable horizontal stabilizer that is automatically positioned by wing flap operating system.

**Some Pros and Cons of the Delta.** J. G. Willis. *The Aeroplane*, Vol. 81, No. 2100, October 19, 1951, pp. 524–527, illus. Design aspects and trends and advantages and disadvantages of the delta wing.

## Aviation Medicine (19)

**The Diurnal Intensity Variation of the Heavy Primaries of Cosmic Radiation and Its Consequences for the Hazard to Health in Flight at Extreme Altitudes.** Herman J. Schaefer. *Journal of Aviation Medicine*, Vol. 22, No. 5, October, 1951, pp. 351–357, illus.

**Gamma Radiation from the Instruments in Aircraft.** A. Morrison. *Journal of Aviation Medicine*, Vol. 22, No. 5, October, 1951, p. 350. Measurements from the instruments in a Lockheed Constellation.

**Where Does Space Begin?** Hubertus Strughold, Heinz Haber, Konrad Buettner, and Fritz Haber. *Journal of Aviation Medicine*, Vol. 22, No. 5, October, 1951, pp. 342–349, 357. 24 references. Functional concept of the boundaries between atmosphere and space with emphasis on the space medical aspects.

**The Effects of Time and Temperature upon Tolerance to Positive Acceleration.** Ernest E. Martin and James P. Henry. *Journal of Aviation Medicine*, Vol. 22, No. 5, October, 1951, pp. 382–390, illus. Analysis of the effects of prolonged acceleration (up to 2 min.) encountered in normal flight performance of high-speed bomber aircraft.

**Problems of High Altitude Flight.** Sidney I. Brody. *United States Naval Institute, Proceedings*, Vol. 77, No. 11, November, 1951, pp. 1191–1195. Physiologic limitations of high altitude flying.

**Eyes, Speed, and Altitude.** Glenn T. Eagleston and Bruce H. Hinton. *Air University Quarterly Review*, Vol. 4, No. 4, pp. 83,

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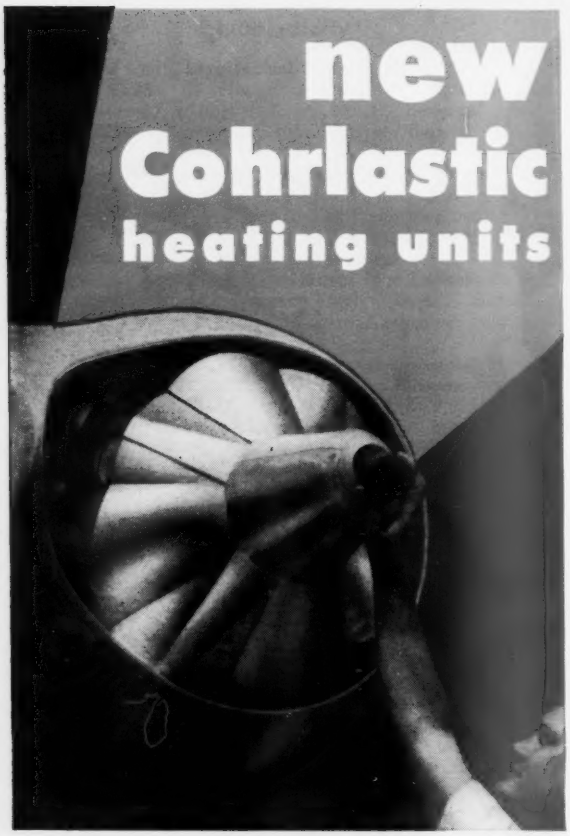


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84. Problems of seeing and sighting enemy aircraft at high speeds and altitudes.

**Escape.** *Air University Quarterly Review*, Vol. 4, No. 4, pp. 37–39, illus. Physical, psychological, and mechanical problems of pilots at high altitudes and in escape attempts.

**High Altitude Bailouts.** Vincent Mazza. *Journal of Aviation Medicine*, Vol. 22, No. 5, October, 1951, pp. 403–407. Results of Air Force test program on escape from aircraft at high altitudes above 40,000 ft.; free-fall conditions.

**Human Factors in Jet Bomber Operation.** D. C. Heimburger. *Air University Quarterly Review*, Vol. 4, No. 4, Summer, 1951, pp. 31–36, illus. Factors affecting escape from high-performance aircraft; escape equipment.

**Comparative Analysis of an Airborne Acceleration Laboratory Versus the Human Centrifuge.** C. F. Gell. *Journal of Aviation Medicine*, Vol. 22, No. 5, October, 1951, pp. 375–381, 390, illus.

## Comfortization (23)

**The AiResearch Cabin Compressor for Lockheed Constellation Type 749 Aircraft.** F. J. Ellen. *The Technical Instructor*, Vol. 6, No. 8, August, 1951, pp. 3–14, illus.

**Pressurizing in Practice.** *The Aeroplane*, Vol. 81, No. 2101, October 26, 1951, pp. 556–558, cutaway drawings.

Layouts of equipment for pressurization of the fuselage in the Armstrong Whitworth Apollo, Handley Page Hermes 4, Bristol Brabazon, Avro Ashton, Vickers Viscount, Airspeed Ambassador, and de Havilland Comet.

## Education & Training (38)

**PanAm Building DC-6B Flight Simulator.** George L. Christian. *Aviation Week*, Vol. 55, No. 21, November 19, 1951, pp. 66–68, illus.

**Practice Makes Perfect.** A. J. Plowman. *The Aeroplane*, Vol. 81, No. 2102, November 2, 1951, pp. 582, 583, illus.

Long-distance overseas training flights for navigation students in Britain; details of a training flight to Sweden.

## Electronics (3)

### ANTENNAS

**The Use of Complementary Slots in Aircraft Antenna Impedance Measurements.** J. T. Bolljahn and J. V. N. Granger. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 11, November, 1951, pp. 1445–1448, illus. 7 references.

A modeling technique suitable for studying the impedance properties of aircraft wing-cap and tail-cap antennas. Impedance measurements are made on a slot complementary to a model that consists of two or more strip conductors lying in a plane and arranged to simulate the shape of the aircraft. The impedance for the aircraft model configuration is calculated from the measured impedance of the slot by using Babinet's principle.

**The Measurement of Antenna Impedance Using a Receiving Antenna.** E. O. Hartig, R. King, T. Morita, and D. G. Wilson. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 11, November, 1951, pp. 1458–1460, illus. 7 references.

**Ferromagnetic Loop Antennas.** W. J. Polydoroff. *Radio & Television News*, Vol. 46, No. 5, November, 1951, *Radio-Electronic Engineering*, pp. 11–13, 24. 4 references. Functions of ferromagnetic cores in loop antennas.

**Determination of Aperture Parameters by Electrolytic-Tank Measurements.** Seymour B. Cohn. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 11, November, 1951, pp. 1416–1421, illus. 7 references.

Determination of the electric and magnetic polarizabilities of an aperture by electrolytic-tank measurements. Measured magnetic-polarizability data are given for rectangular-, rounded-slot-, cross-, rosette-, dumbbell-, and H-shaped apertures.

**Radiation Resistance of a Two-Wire Line.** James E. Storer and Ronold King. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 11, November, 1951, pp. 1408–1412, illus. 11 references.

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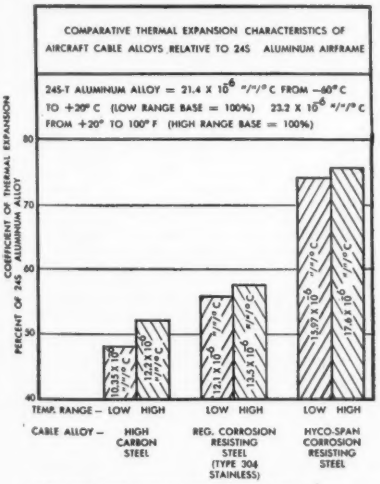
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## CIRCUITS & CIRCUIT ELEMENTS

**Precise Solutions of Linear Simultaneous Equations Using a Low Cost Analog.** Sumner Ackerman. *Review of Scientific Instruments*, Vol. 22, No. 10, October, 1951.

Design, circuits, and principles of operation of a low cost analog computer that, when used in conjunction with techniques that can be handled by standard desk calculators, can solve systems of linear simultaneous equations to any degree of accuracy.

**An Introduction to Computer Concepts, III.** John D. Goodell. *Radio & Television News*, Vol. 46, No. 4, October, 1951, *Radio-Electronic Engineering*, pp. 14–16, illus. Digital and analog computers; comparison of computing mechanisms with the human mind.

**An Electrostatic-Tube Storage System.** A. J. Lephakis. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 11, November, 1951, pp. 1413–1415, illus. 3 references.

A system for storing binary pulses which contains two storage channels, each consisting of an M.I.T. electrostatic storage tube and the circuits needed to operate the tube. The system may be used to compress, expand, or delay a group of pulses.

**The Pulse Standardizer.** Robert R. Rathbone. *Radio & Television News*, Vol. 46, No. 5, November, 1951, *Radio-Electronic Engineering*, pp. 6, 7, 31, illus.

A pulse standardizer, built at M.I.T. Servomechanism Laboratory, which combines an inverter and R-L-C speaker for standardizing pulse repetition frequencies at 2 mc. The standardizer takes pulses of various amplitudes and shapes and reforms them into 0.1 μsec., half-sine-wave pulses; the circuits are insensitive to variations in the input.

**Gate and Delay Generator.** Robert R. Rathbone. *Radio & Television News*, Vol. 46, No. 4, October, 1951, *Radio-Electronic Engineering*, pp. 10, 11, 24, illus. Circuits and operation of a generator that provides a rectangular gate variable from 0.5 to 2,500 μsec., and a 0.1 μsec. pulse.

**Production of Short Pulses from a Simple *LCR* Circuit.** F. A. Benson and G. V. G. Lusher. *Electronic Engineering*, Vol. 23, No. 285, November, 1951, pp. 446, 447, illus.

**Alignment and Adjustment of Synchronously Tuned Multiple-Resonant-Circuit Filters.** Milton Dishal. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 11, November, 1951, pp. 1448–1455, illus. 4 references. Theory and principles for the alignment and adjustment procedures in tuning up a multiple-resonant-circuit filter.

**Per-Cent Ripple Nomographs.** Charles F. Halm. *Radio & Television News*, Vol. 46, No. 4, October, 1951, *Radio-Electronic Engineering*, pp. 31, 32. For single and double section choke input filters.

**The Parallel-T Network as a Linear Mixer.** J. S. Nisbet. *Electronic Engineering*, Vol. 23, No. 285, November, 1951, pp. 432, 433, illus. 3 references. Calculation of the optimum transfer ratio, input impedance, and sensitivity for mixing the output of two oscillators by using a parallel-*T* network; mixer circuit.

**The Multisection RC Filter Network Problem.** L. Storch. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 11, November, 1951, pp. 1456–1458. 5 references.

**The Series Amplifier.** Edward L. Crosby, Jr. *Radio & Television News*, Vol. 46, No. 4, October, 1951, *Radio-Electronic Engineering*, pp. 12, 13, 30, illus.

Miniaturization technique that does not use printed circuits or subminiature components but omits many components from the conventional design. The tubes of the amplifier are connected in series, eliminating the decoupling circuits. Plate voltages are not stabilized. Circuits for a high-gain, wide-band, intermediate frequency amplifier illustrate the design technique, but it can be used to build other units.

## COMMUNICATIONS

**On the Definition of Information.** Edgar Reich. *Journal of Mathematics & Physics*, Vol. 30, No. 3, October, 1951, pp. 156–161. 3 references.

Approach to a definition of communication by postulating an invariance under certain types of transformations, based on Shannon's formulation of a statistical theory of information.

## COMPONENTS

**Artificial Dielectrics for Microwaves.** W. M. Sharpless. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 11, November, 1951, pp. 1389–1393, illus. 9 references.

A procedure for measuring the dielectric properties of metal-loaded artificial dielectrics in the microwave region by the use of the short-circuited line method. Formulas, based on transmission-line theory, are included and serve as guides in predicting the approximate dielectric properties of certain loading configurations.

**Theory of Barium Titanate. II.** A. F. Devonshire. *Philosophical Magazine*, Vol. 42, (7th Series) No. 333, October, 1951, pp. 1065–1079, illus. 12 references. Calculation of the piezoelectric constants, clamped dielectric constants, and elastic constants for constant field.

**New Views on Oxidic Semi-Conductors and Zinc-Sulphide Phosphors.** E. J. W. Verwey and F. A. Kröger. *Philips Technical Review*, Vol. 13, No. 4, October, 1951, pp. 90–95, illus. 6 references.

**Crystal Diodes in Modern Electronics. I.** David T. Armstrong. *Radio & Television News*, Vol. 46, No. 4, October, 1951, pp. 47–50, 162–166, illus. Fundamental design characteristics of germanium crystal diodes.

**Germanium Crystal Valves; An Assessment of Characteristics and Applications.** B. R. A. Bettridge. *Electronic Engineering*, Vol. 23, No. 285, November, 1951, pp. 414–417, illus. 1 reference.

## CONSTRUCTION TECHNIQUES

**Circuit Printers for Flat and Cylindrical Surfaces.** *U.S., National Bureau of Standards, Technical News Bulletin*, Vol. 35, No. 11, November, 1951, pp. 168–170, illus. 4 references. Design and operation of two semi-automatic machines for printing electronic circuits on flat and cylindrical surfaces.

## ELECTRONIC CONTROLS

**Mechanical Design Aspects of Electronic Controls.** M. Goldstein. *Product Engineering*, Vol. 22, No. 11, November, 1951, pp. 191–195, illus. Components and panel design and specialized assembly methods for producing industrial electronic controls.

## ELECTRONIC TUBES

**The Measurement of Microphony in Valves.** R. Bird. *Electronic Engineering*, Vol. 23, No. 285, November, 1951, pp. 429–431, illus. 1 reference. Optic and electric measurement techniques; structural recommendations for reducing microphony.

**New Electronic Tubes Employed as Switches in Communication Engineering. II—Switch Tubes.** J. L. H. Jonker and Z. van Gelder. *Philips Technical Review*, Vol. 13, No. 4, October, 1951, pp. 82–89, illus. 4 references.

## MEASUREMENTS & TESTING

**ILS Field Test Set.** Charles L. Ellis. *Radio & Television News*, Vol. 46, No. 5, November, 1951, *Radio-Electronic Engineering*, pp. 3–5, 25, 26, illus.

Design and operation of the Gables Engineering, Inc. Model G-250A ILS Field Test set. Designed for air-line uses, the unit simulates I.L.S. and marker transmitter signals to check performance of the complete aircraft I.L.S. installation.

**Square Wave Testing Simplified.** Harold E. Bryan. *Audio Engineering*, Vol. 35, No. 10, October, 1951, pp. 14, 15, 46, illus. 6 references.

Simplified expressions for the reproduced wave shape from a given square-wave frequency and their uses to determine the practical response limits of an amplifier.

**A Precise Sweep-Frequency Method of Vector Impedance Measurement.** D. A. Alsberg. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 11, November, 1951, pp. 1393–1400, illus. 3 references.

**Electronic Instruments for Mechanical Measurements.** J. L. Murphy. *Product Engineering*, Vol. 22, No. 11, November, 1951, pp. 153–159, illus. Design of equipment built at Armour Research Foundation to solve stress measurement problems for which commercial equipment is not suitable.

## NAVIGATION AIDS

**A Beacon Range Indicator.** J. H. McGuire. *Electronic Engineering*, Vol. 23, No. 285, November, 1951, pp. 436–439, illus. 3 references.

Proposal for a beacon range indicator that uses pulse techniques to determine the range of an aircraft by interrogating a slave beacon on the ground; schematic diagram of the indicator; circuit

diagrams, function, and operation of the pulse group selector and the pulse position indicator.

### NOISE & INTERFERENCE

**Heater Hum in Amplifiers.** *U.S., National Bureau of Standards, Technical News Bulletin*, Vol. 35, No. 11, November, 1951, pp. 160, 161, illus. Investigation of tube and circuit selection for minimizing heater hum in low-level amplifiers.

### POWER SUPPLIES

**Carrier-Type Regulated Power Supply.** Joseph Houle. *Radio & Television News*, Vol. 46, No. 5, November, 1951, *Radio-Electronic Engineering*, pp. 14, 15, 31, illus. 6 references.

Performance of a power-supply regulator that uses a carrier amplifier and has a continuously variable output of 0–300 volts d.c., a regulation of 0.1 volt over load range 0–50 milliamperes, and a hum level of 3 millivolts; diagram of circuit and parts values.

### TRANSMISSION LINES

**Square Wave Guide Attenuation; A Nomograph for Determining the Attenuation of the $TE_{1,1}$ Mode in a Square Air-Dielectric Wave Guide.** *Radio & Television News*, Vol. 46, No. 5, November, 1951, *Radio-Electronic Engineering*, p. 32.

### WAVE PROPAGATION

**Scattering of Electromagnetic Waves from Two Concentric Spheres.** Arthur L. Aden and Milton Kerker. *Journal of Applied Physics*, Vol. 22, No. 10, October, 1951, pp. 1242–1246, illus. 3 references. Solution for the scattering of plane electromagnetic waves from a sphere with a concentric spherical shell.

**Scattering of Plane Waves by Soft Obstacles. II—Scattering by Cylinders, Spheroids, and Disks.** Elliott W. Montroll and Robert W. Hart. *Journal of Applied Physics*, Vol. 22, No. 10, October, 1951, pp. 1278–1289, illus. 14 references.

**Propagation at 412 Megacycles from a High-Power Transmitter.** Irvin H. Gerks. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 11, November, 1951, pp. 1374–1382, illus. 19 references.

**Notes on the Analysis of Radio-Propagation Data.** R. P. Decker. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 11, November, 1951, pp. 1382–1388, illus. 3 references.

## Equipment

**British Standard Identification Scheme for Aircraft Pipe Lines (British Standard B.S. M.23, July, 1951).** *The Technical Instructor*, Vol. 6, No. 9, September, 1951, pp. 3–6, illus.

### ELECTRIC (16)

**The Modern Approach to Electrical Machine Analysis.** W. J. Gibbs. II, III, IV, V. *The Engineer*, Vol. 192, Nos. 4995, 4996, 4997, 4998, October 19, 26, November 2, 9, 1951, pp. 485–488; 517–520; 546–548; 578–580, illus.

### HYDRAULIC & PNEUMATIC

**Aqueous Nonflammable Hydraulic Fluids.** J. E. Brophy, V. G. Fitzsimmons, J. G. O'Rear, T. R. Price, and W. A. Zisman. *Industrial and Engineering Chemistry*, Vol. 43, No. 4, April, 1951, pp. 884–896, illus. 18 references.

Chemical composition, properties, and mechanical performance of nonflammable hydraulic fluids. Designated as Hydrolubes, these fluids are polymer-thickened, corrosion-inhibited, aqueous solutions.

**Power-Operated Flying Controls. I, II.** R. Westbury. *Flight*, Vol. 60, Nos. 2232, 2233, November 2, 9, 1951, pp. 570, 571; 597–599, illus.

**I.** Operating requirements, structure, and types of single-unit hydraulic controls; comparison of the advantages of electric and hydraulic sources of power, and of the efficiency of systems controlled by variable stroke pumps and those controlled by screw-jacks. **II.** Possible causes of failure; main features of power-assisted and duplicated power controls produced by H. M. Hobson, Ltd. for new aircraft types.

**Aircraft Pneumatics.** H. R. Hearle. *The Technical Instructor*, Vol. 6, No. 4, April, 1951, pp. 3–15, illus.

Review of uses of compressed air on aircraft; advantages of pneumatics for ancillary power services on aircraft; example of satisfactorily operating aircraft, using pressure systems up to 1,000 lbs. per sq.in.

**Pneumatics Increases Range of Navy Flying Boat.** Edmund C. Powers. *Applied Hydraulics*, Vol. 4, No. 11, November, 1951, pp. 70–73, illus.

Design and operation of a high-pressure pneumatic system for actuation of bomb bay doors and similar operations, and of a low-pressure pneumatic system for starters and auxiliary powers for turbine engines, incorporated in the Convair XP5Y-1.

## Flight Operating Problems (31)

### HIGH-ALTITUDE FLIGHT

**Problems of High Altitude Flight.** Sidney I. Brody. *United States Naval Institute, Proceedings*, Vol. 77, No. 11, November, 1951, pp. 1191–1195. Factors affecting aircraft performance at high altitudes.

### HIGH-SPEED FLIGHT

**Requirements for Protection Against Thermal Hazards of High Speed Flight.** DeArmond Lindes. *Journal of Aviation Medicine*, Vol. 22, No. 5, October, 1951, pp. 358–364, 426, illus. Factors involved in aircraft heat balance (heat gains and heat losses from internal and external sources); refrigeration systems.

**Supersonic Flight from the Pilot's View.** William B. Bridgeman. *Aeronautical Engineering Review*, Vol. 11, No. 2, February, 1952, pp. 24–28, illus. Piloting experience and problems in flying the Navy-Douglas D588-2 Skyrocket.

### ICE PREVENTION & REMOVAL

**The Physics of the Mechanical Removal of Ice from Aircraft.** D. L. Loughborough. *Aeronautical Engineering Review*, Vol. 11, No. 2, February, 1952, pp. 29–34, illus. 9 references.

Theoretical analysis of the operation of a De-Icer. The stresses produced on a De-Icer surface are approximated and given values that can be used in calculating a reasonable value for the adhesion of ice to rubber. These approximations are then applied to the problem of the action of the tube area in relation to the diameter of the tube area.

**Intermittent Heating for Aircraft Ice Protection with Application to Propellers and Jet Engines.** Myron Tribus. *American Society of Mechanical Engineers, Transactions*, Vol. 73, No. 8, November, 1951, pp. 1117–1128, Discussion, pp. 1128–1130, illus. 20 references.

Design equations for ice-prevention equipment using intermittent heating; solution of the equations by means of an electric analog technique; comparison of results with previously reported data; evaluation of intermittent heating as compared with continuous heating; power requirements and recommendations for reducing the power needed.

**Further Remarks on Intermittent Heating for Aircraft Ice Protection.** Frederick Weiner. *American Society of Mechanical Engineers, Transactions*, Vol. 73, No. 8, November, 1951, pp. 1131–1137, illus. 7 references.

Extension of the application of the electric analog technique to an internally-heated propeller blade; comparison with previously reported time-temperature data; examination of the power-density requirements for the heated area.

**An Investigation of Aircraft Heaters. XXXVIII—Determination of Thermal Performance of Rectangular- and Trapezoidal-Shaped Inner-Skin Passages for Anti-Icing Systems.** L. M. K. Boelter, V. D. Sanders, and F. E. Romie. *U.S., N.A.C.A., Technical Note No. 2524*, November, 1951. 21 pp., illus. 10 references.

**Learning More About Aircraft; Icing Low Temperature Laboratory.** D. Fraser. *Canada, National Aeronautical Establishment, Quarterly Bulletin, Report No. NAE 1951 (3)*, July 1–September 30, 1951, pp. 1–5, illus.

Problems in gathering precise icing data and in extrapolating such data to weather conditions leading to flight cancellation, and to jet aircraft altitudes; new instruments for detection and measurement of icing; data obtained during 1950 and 1951 North Star icing test flights.

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### NEWS NOTES FROM LOCKHEED

Eight international airlines have now ordered Super Constellations—most recent: Seaboard & Western Airlines and Braathens S.A.F.E. Air Transport . . . With Navy and Air Force orders, the total demand now exceeds 200. . . . A new "White House Squadron" of Lockheed F-94 All Weather Jet Fighters is guarding Washington, D.C. . . . Lockheed is occupied with aircraft using six different kinds of power, including reciprocating engines, turbo-props, jets and rocket power. . . . For pilot comfort every Lockheed jet fighter has a cockpit cooling system equivalent to 100 household refrigerators. . . . The single Allison jet engine in the Lockheed T-33 jet trainer is more powerful than all four engines of the B-17 bomber of World War II fame. . . . Pilots of many nations learn jet flying in Lockheed T-33 trainers, and recently when two T-33's were delivered to Turkey they were inaugurated in preflight Mohammedan rites including a lamb sacrifice.

### FROM THE WORLD PRESS

Under the headline, "New Facts on Jet Combat," *Aviation Week* reports from Tokyo: "The Lockheed F-80 *(Shooting Star)* still is considered to be the best ground-attack jet in Korea. There is considerable belief here that development of an airplane along the proved lines of the F-80 is the answer to the interdiction-close support requirement." Thus another Lockheed design continues to prove its basic "rightness" even though more modern types have replaced it in Lockheed's production line.


1951

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## Flight Safety & Rescue (15)

**Lessons from an Accident; Findings of the Court Investigation into the Loss of Viking G-AHPN.** *Flight*, Vol. 60, No. 2230, October 19, 1951, pp. 518, 519, illus.

**Safety and Civil Aircraft.** W. Tye. *The Aeroplane*, Vol. 81, No. 2100, October 19, 1951, pp. 519, 520, illus. (Summary of an R.Ae.S. lecture, October 18, 1951.)

**Air Rescue and Survival.** Robert Bicknell. *The Technical Instructor*, Vol. 6, No. 5, May, 1951, pp. 3–14, illus. Equipment and possibilities for survival of aircraft personnel under crash conditions in present-day high-speed aircraft.

**The Navy Program for Aircraft Escape.** R. L. Christy. *Journal of Aviation Medicine*, Vol. 22, No. 5, October, 1951, pp. 408–413, illus. Improvements in escape techniques; ejection seat and ejection cockpit capsule design and performance.

## Fuels & Lubricants (12)

**Antiknock Antagonists.** H. K. Livingston. *Industrial and Engineering Chemistry*, Vol. 43, No. 3, March, 1951, pp. 663–671 illus. 23 references.

A mechanism of antiknock action is proposed, based on an analysis of the relative harmfulness of the effect of various compounds on the octane number of leaded gasolines.

**Formation of Engine-Deposit Compounds by Solid-State Reactions; X-Ray Diffraction Study.** Francis W. Lamb and Leonard M. Niebylski. *Analytical Chemistry*, Vol. 23, No. 10, pp. 1388–1397, illus. 27 references. A study of lead compounds in reciprocating engine deposits.

**Determination of Tetraethyllead in Gasoline by X-Ray Absorption.** Samuel W. Levine and A. H. Okamoto. *Analytical Chemistry*, Vol. 23, No. 9, September, 1951, pp. 1293–1296, illus. 8 references.

**Relation of Octane Number to Cool Flame Formation.** M. R. Barusch and J. Q. Payne. *Industrial and Engineering Chemistry*, Vol. 43, No. 10, October, 1951, pp. 2329–2332, illus. 7 references. An investigation into the knock resistance of fuel.

**Abadan and Aviation Fuels.** *Flight*, Vol. 60, No. 2231, October 26, 1951, pp. 540, 541, illus. The nature of high-octane aviation fuels and methods of refining; work at the Abadan (Iran) refinery.

**Properties of High Boiling Petroleum Products; Physical and Chemical Characterization Studies with Relation to Polynuclear Aromatic Components.** G. G. Wanless, L. T. Eby, and John Rehner, Jr. *Analytical Chemistry*, Vol. 23, No. 4, April, 1951, pp. 563–571, illus. 21 references.

**Explosive Characteristics of Hydrogen Peroxide Vapor.** Charles N. Satterfield, George M. Kavanagh, and Hyman Resnick. *Industrial and Engineering Chemistry*, Vol. 43, No. 11, November, 1951, pp. 2507–2514, illus. 13 references. Quantitative study of the explosive characteristics; mechanism of explosion.

**Viscosity Index Improvers for Lubricating Oils; Polyvinyl Esters of Long-Chain Fatty Acids.** William S. Port, James W. O'Brien, John E. Hansen, and Daniel Swern. *Industrial and Engineering Chemistry*, Vol. 43, No. 9, pp. 2105–2107, illus. 16 references.

**Spectrographic Analysis of New and Used Lubricating Oils.** C. M. Gambrill, A. G. Gassmann, and W. R. O'Neill. *Analytic Chemistry*, Vol. 23, No. 10, October, 1951, pp. 1365–1369, illus. 7 references.

## Gliders (35)

**Germany's First Post-War Sailplane, Doppelraab.** Fritz Raab. *Sailplane and Glider*, Vol. 19, No. 11, November, 1951, pp. 242, 243, illus.

**High Performance Two-Seater Mü-13 E "Bergfalke."** *Sailplane and Glider*, Vol. 19, No. 11, November, 1951, pp. 257, 260, 263, illus.

## Guided Missiles (1)

**Rocket Realities.** Norman S. Currey. *Canadian Aviation*, Vol. 24, No. 11, November, 1951, pp. 20, 21, illus. Brief summary of the history and future trends of rocket development.

**The "Wasserfall" Remote-Controlled A/A Missile.** Rudolf H. Reichel. *Interavia*, Vol. 6, No. 10, October, 1951, pp. 569–574, illus. 2 references.

Aerodynamic considerations, control system, and power-plant design of the Wasserfall supersonic antiaircraft missile developed at Peenemünde during World War II; propellant selection; technical performance and operational test results.

**Guided Anti-Aircraft Missiles.** *Interavia*, Vol. 6, No. 10, October, 1951, pp. 554, 555, illus.

Specifications and performance data on guided antiaircraft missiles developed in the U.S. and Europe during and since World War II; effectiveness of this type of weapon; explanation of the impulse system and guide-beam system of missile control; target-homing devices.

**Principles of Missile Guidance Systems.** *Aero Digest*, Vol. 63, No. 5, November, 1951, pp. 88, 90, 92, 94, 96, 98–103, illus. 7 references. Development of guidance systems applicable for specific missile types.

**Aircraft Rockets.** *Interavia*, Vol. 6, No. 1, October, 1951, pp. 551–553, illus. Construction and performance of unguided and guided rocket projectiles. Specifications of U.S. and foreign types are tabulated.

## Instruments (9)

**Combination Open-Cycle Closed-Cycle Systems.** J. R. Moore. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 11, November, 1951, pp. 1421–1432, illus. 16 references.

Combination of an open-cycle system and a closed-cycle system to form an automatic control that is superior to either. The open-cycle system acts as the coarse controller, providing the major portion of the output; the closed-cycle system acts as the vernier controller. The basic theory of nonlinear open-cycle controllers is explained.

**The Practical Application of Frequency Response Analysis to Automatic Process Control.** C. I. Rutherford. *Institution of Mechanical Engineers, Proceedings*, Vol. 162, No. 3, 1950, pp. 334–343, Discussion, pp. 344–354, illus. 11 references.

Basic principles of automatic control systems; analysis and graphic representation of the frequency response of controllers and process elements; phase lag and attenuation; application to the design of automatic controllers.

**Transient Response of a Narrow-Band Automatic Frequency-Control System.** Theodore Miller. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 11, November, 1951, pp. 1433–1436, illus. 4 references.

**Discussion on "The Automatic Compensation of Zero-Drift Errors in Direct-Coupled Feedback Systems" by F. A. Summerlin.** R. G. Lex. **Author's Reply.** *Institution of Electrical Engineers, Proceedings, Part II, Power Engineering*, Vol. 98, No. 65, October, 1951, pp. 641, 642, illus.

**An Electronic Process-Controller.** J. R. Boundy and S. A. Bergen. (*I.E.E., Measurements Section, Paper No. 1109.*) *Institution of Electrical Engineers, Proceedings, Part II, Power Engineering*, Vol. 98, No. 65, October, 1951, pp. 609–615, Discussion, pp. 615–618, illus.

An electronic-process controller in which the d.c. output is used to position the pneumatically-operated process-control valve by an electropneumatic relay mounted on the valve; circuit arrangements, construction, and operation; design of an electronic process analog for testing the controller.

**Design and Analysis of a Conservative Dynamic Load Simulator.** E. H. Gamble and B. W. Hatten. *Journal of Applied Physics*, Vol. 22, No. 10, October, 1951, pp. 1250–1257, illus. 5 references.

An analysis, neglecting coulomb friction, of a dynamic load simulator that returns energy adsorbed from an item under test to the electric power lines; application of the basic design to control load simulators suitable for testing autopilot servos and aircraft control systems.

**Theory of Operation of the Vane-Type Prestall Detector.** W. Kenneth Bullivant. *Aeronautical Engineering Review*, Vol. 11, No. 2, February, 1952, pp. 39–45, illus. 6 references.

Theory of the operation of Safe Flight Instrument Corp.'s vane-type warning and prestall detection device, based on data for pressure distributions over portions of an NACA 230 series plain wing and an NACA 66 series plain and flapped wing; effects of detector response characteristics on aircraft parameters; applicability of the instrument.

**Measurement of Instantaneous Vector Air Velocity by Hot-Wire Methods.** Carl E. Pearson. *Journal of the Aeronautical Sciences*, Vol. 19, No. 2, February, 1952, pp. 73–82, illus.

Theory, construction, and use of a hot-wire probe for obtaining the average and instantaneous vector velocity of airflow behind the impeller of a compressor; correction method for compensating for the fluctuation in the wire characteristics and response at operating levels; validity of data obtained with the hot-wire probe.

**A Study of the Requirements for Background Lighting of Aircraft Instruments and Lucite Illuminated Consoles. III—Investigations in the Floodlighting of Transilluminated Cockpit Displays.** David Alsher and John Lazo. *U.S., Naval Air Experimental Station, Aeronautical Medical Equipment Laboratory, Philadelphia, Report TED No. NAM EL-600*, October 17, 1951. 15 pp., illus. 11 references.

**Gamma Radiation from the Instruments in Aircraft.** A. Morrison. *Journal of Aviation Medicine*, Vol. 22, No. 5, October, 1951, p. 350. Measurements of radiation from the instruments in a Lockheed Constellation.

**Minimum Phase Networks.** J. A. Tanner. *Electronic Engineering*, Vol. 23, No. 285, November, 1951, pp. 418–423, illus. 7 references. Summary of the characteristics and properties of minimum phase networks with regard to their use in servosystems.

**Five Ways To Use Bonded-Wire Strain Gages.** F. G. Tatnall. *SAE Journal*, Vol. 59, No. 11, November, 1951, pp. 28, 29, illus. (Based on a paper: Methods for Evaluating Loads and Stresses for Machine Design.)

**A Multiple-Range Self-Balancing Thermocouple Potentiometer.** I. Warshawsky and M. Estrin. *U.S., N.A.C.A., Research Memorandum No. E51H31*, November 5, 1951. 15 pp., illus.

Basic principles of operation and design details of a multiple-range potentiometer circuit that provides automatic measurement of temperatures or temperature differences with any one of several thermocouple-material pairs. Reference-junction compensation and simultaneous span alteration permit rapid selection of any one of a large number of temperature ranges.

**A Photographic Pyrometer.** Donald W. Male. *Review of Scientific Instruments*, Vol. 22, No. 10, October, 1951, pp. 769–772, illus. 1 reference.

A photographic pyrometer, originally designed for ram-jet temperatures from 2,000° to 3,200°F., which indicates apparent surface temperatures by photographing hot surfaces and correlating the variable density of the negative with the apparent surface temperature. The apparent temperatures of all areas of the photographed region can be determined simultaneously and instantaneously.

## Lighter-than-Air (40)

**Modern Montgolfier.** L. Arthur. *Flight*, Vol. 60, No. 2232 November 2, 1951, pp. 560, 561, illus. Theoretical outline for a jet-heated, jet-propelled, hot-air dirigible weapon.

## Machine Elements (14)

### BEARINGS

**Discrepancies Between Theoretical and Observed Behavior of Cyclically Loaded Bearings.** R. W. Dayton, E. M. Simons, and F. A. Fend. *U.S., N.A.C.A., Technical Note No. 2545*, November, 1951, 27 pp., illus. 8 references.

Analysis of the causes of the discrepancies between theoretical and experimental values of eccentricity ratios of a cyclically loaded shaft rotating in a sleeve bearing; evaluation of the effects of deviations from ideal test conditions; factors influencing behavior.

**The Effect of Macro-Roughness on the Performance of Parallel Thrust Bearings.** M. E. Salama. *Institution of Mechanical Engineers, Proceedings*, Vol. 163, *War Emergency Proceedings No. 59, Applied Mechanics*, 1950, pp. 149–158, Discussion, pp. 158–161, illus. 2 references.

**Aircraft Turbosupercharger Bearings—Their History, Design, and Application Technique.** S. R. Puffer. *American Society of Mechanical Engineers, Transactions*, Vol. 73, No. 8, November, 1951, pp. 1077–1084, illus.

**How To Get Good Sleeve Bearing Life.** Richard J. Schager. *SAE Journal*, Vol. 59, No. 11, November, 1951, pp. 40–44, illus. (Excerpts from a paper: Sleeve Bearing—Design, Manufacture, and Installation.)

**Bearings, Lubricants, and Lubrication; A Digest of 1950 Literature.** *Mechanical Engineering*, Vol. 73, No. 11, November, 1951, pp. 892–895. 72 references.

### FASTENINGS

**Sealing for Altitude.** Gilbert G. Close. *Aviation Age*, Vol. 16, No. 5, November, 1951, pp. 11–13, illus. Development of the Lock-O-Seal method of sealing aircraft bolts and of Chan-O-Sealing for protection on continuous joints between aircraft components and sections.

### FRICTION

**The Variation of the Coefficient of Static Friction with the Rate of Application of the Tangential Force.** R. C. Parker, W. Farnworth, and R. Milne. *Institution of Mechanical Engineers, Proceedings*, Vol. 163, *War Emergency Proceedings No. 59, Applied Mechanics*, 1950, pp. 176–184, illus. 9 references.

### GEARS & CAMS

**Gear-Tooth Stresses at High Speed.** W. A. Tuplin. *Institution of Mechanical Engineers, Proceedings*, Vol. 163, *War Emergency Proceedings No. 59, Applied Mechanics*, 1950, pp. 162–167, Discussion, pp. 167–175, illus. Study of the stresses induced in straight-tooth spur gear teeth by errors in pitch.

### MECHANISMS & LINKAGES

**Linkage Layout.** Eugene W. Pike, Thomas R. Silverberg, and Philip T. Nickson. *Machine Design*, Vol. 23, No. 11, November, 1951, pp. 105–110, 194, illus. 8 references.

Systematic procedures for designing linkages that will reproduce arbitrarily prespecified relationships between motions; matching desired motions with suitable linkages; evaluation of five layout methods; use of corrective cams for more precise results.

### SPRINGS

**Working Stresses for Helical Springs.** *Machine Design*, Vol. 23, No. 11, November, 1951, pp. 134–140, 190, illus. Establishing maximum design stress of spring wire materials by fatigue testing machines; interpretation of test results.

## Materials (8)

**Apparatus for Low-Temperature Tension Tests of Metals.** Robert J. Mosborg. *American Society for Testing Materials, Bulletin*, No. 177, October, 1951, pp. 41–44, illus.

Procedure and equipment used at the University of Illinois for tests at temperatures down to −321°F. on steel and copper under slowly applied static loads; test results include typical time-temperature curves.

**A Theory of Rockwell Ball Hardness.** M. A. du Toit Meyer. *Applied Scientific Research, Section B, Electrophysics, Acoustics, Optics, Mathematical Methods*, Vol. A3, No. 1, 1951, pp. 11–26, illus. 11 references. A theoretical analysis of the Rockwell ball hardness tester; comparison with test results.

**The Measurement of the Dynamic Modulus of Elastomers by a Vector Subtraction Method.** C. W. Painter. *American Society for Testing Materials, Bulletin*, No. 177, October, 1951, pp. 45–57, illus. 4 references.

Design and performance of a flexometer and the associated recording equipment for measuring dynamic modulus and hysteresis in elastomers; temperature effects; accuracy and range of equipment.

**Quantitative Analysis with Infrared Spectrophotometers.** David Z. Robinson. *Analytical Chemistry*, Vol. 23, No. 2, February, 1951, pp. 273–277, illus. 5 references. Systematic outline of some errors in analysis with double- and single-beam infrared spectrophotometers.

**Effect of Finite Slit Width on Infrared Absorption Measurements.** A. R. Philpotts, William Thain, and P. G. Smith. *Analytical Chemistry*, Vol. 23, No. 2, February, 1951, pp. 268–272, illus. 11 references.

**Rotogenerative Detection of Corrosion Currents.** Joseph B. McAndrew, William H. Colner, and Howard T. Francis. *U.S.*,

*Always the same* . . . product quality that never varies . . . that's the secret of Aeroquip's leadership. Nothing is spared in time, money and effort to obtain the newest, most accurate inspection equipment to assure the Aeroquip standard, highest in the industry. That is why Aeroquip Products are "Always First" in quality.

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**Ceramic Coatings; For Metal Protection at High Temperatures.** *Product Engineering*, Vol. 22, No. 11, November, 1951, pp. 177–179, illus. Development of ceramic-coated low-alloy steel by Stewart Warner Corp.

## CORROSION & PROTECTIVE COATINGS

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Naval specifications for corrosion prevention; practicalities of using vapor phase inhibitors on aircraft engines; protection of electronic equipment and armament; preservation and maintenance procedures for idle aircraft.

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Dynamic stress tests on a single-phase material in a model SF-4 Sonntag Direct Stress Fatigue-Testing machine. The static stress was held constant and the dynamic stress was varied from 0 per cent of the static stress to as close to 100 per cent as practicable.

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Advantages and applications of melting and sintering in a vacuum; design and problems connected with the use of a high-vacuum melting furnace suitable for treating 50 to 100 lbs. of steel.

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**Thermodynamic Functions of Iron.** L. S. Darken and R. P. Smith. *Industrial and Engineering Chemistry*, Vol. 43, No. 8, August, 1951, pp. 1815–1820, illus. 35 references.

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**Nimonic.** Denis Desoutter. *Aviation Age*, Vol. 16, No. 5, November, 1951, pp. 44–49, illus. Composition, characteristics, and methods of producing Nimonic alloys in Britain; combustion chamber and turbine-blade applications.

**Letters to the Editor: Fracture and Yield Stress of 1020 Steel at Low Temperatures.** A. S. Eldin and S. C. Collins. *Journal of Applied Physics*, Vol. 22, No. 10, October, 1951, pp. 1296, 1297, illus.

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**A Realistic Approach to the Use of Titanium.** Herman H. Hanink. *Product Engineering*, Vol. 22, No. 11, November, 1951, pp. 164–171, illus.

Tests at Wright Aeronautical Corp. to determine the mechanical properties of hot-rolled and annealed titanium alloys and the behavior of machined titanium components subject to dynamic loading under simulated engine operating conditions.

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**Some Notes on Synthetic Resin Adhesives.** F. G. Swanborough. *The Aeroplane*, Vol. 81, No. 2103, November 9, 1951, pp. 616–619, illus. General characteristics and applications of synthetic resin adhesives for metal-to-metal and metal-to-non-metal bonding, with special reference to Ardux, Redux, Aerolite, and Araldite.

**Adhesives in Machine Design.** John Delmonte. *Machine Design*, Vol. 23, No. 11, November, 1951, pp. 96–101, 192, illus. Characteristics, requirements, and principles of applying high bond strength adhesive used in structural assemblies.

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**Properties of New Synthetic Rubbers and Plastics.** G. Bryant Bachman, L. J. Filar, R. W. Finholt, L. V. Heisey, H. M. Hellman, L. L. Lewis, and D. D. Micucci. *Industrial and Engineering*

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**Shock Loading of Plastics.** P. H. Ericksen. *Society of Plastics Engineers, Journal*, Vol. 7, No. 8, October, 1951, pp. 7–9, illus. 4 references. Tests on the resistance of various types of plastics to sudden tensile, shear, or compressive shocks, or to a combination of these shocks.

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**Molded Delta Wing.** *Aircraft Production*, Vol. 13, No. 157, pp. 335–340, illus. 5 references. Structural features and methods of molding wing for small high-speed aircraft, from Durestos, a phenolic-resin impregnated asbestos-laminate.

**Cracking of Stressed Polyethylene; Effect of Chemical Environment.** J. B. DeCoste, F. S. Malm, and V. T. Wallder. *Industrial and Engineering Chemistry*, Vol. 43, No. 1, January, 1951, pp. 117–121, illus. 12 references.

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**Determination of Intrinsic Low Stress Properties of Rubber Compounds; Use of Inclined Plane Tester.** W. B. Dunlap, Jr., C. J. Glaser, Jr., and A. J. Nellen. *Analytical Chemistry*, Vol. 23, No. 4, April, 1951, pp. 638–643, illus. 4 references. Test procedure and apparatus that provide an accurate measurement of rate and state of cure of rubber tire compounds.

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Nondestructive test methods based on the change of electrical resistivity or of the strain produced by a given stress at varying time intervals on the same specimen have been devised for correlating natural aging with accelerated aging and service life.

**Evaluation of Tread Wear.** Dietrich G. Stechert and Thomas D. Bolt. *Analytical Chemistry*, Vol. 23, No. 11, November, 1951, pp. 1641–1646, illus. 5 references.

Development of a method for obtaining a single rating of tread wear for each tire. The method is based on functional relationship between nonskid loss and mileage and measurements of nonskid depth obtained during a test run.

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**A Study of an Analogous Model Giving the Nonlinear Characteristics in the Buckling Theory of Sandwich Cylinders.** Chi-Teh Wang and G. V. R. Rao. *Journal of the Aeronautical Sciences*, Vol. 19, No. 2, February, 1952, pp. 93–100, illus. 10 references.

A qualitative study of the effect of shear rigidity of the core of a sandwich cylinder on the nonlinear characteristics of the buckling phenomenon, based on an analysis of the buckling of sandwich columns supported on sandwich rings. For finite deflections, the rings behave as nonlinear springs.

**Durability Tests of Metalite Sandwich Construction.** D. G. Reid. (*American Society for Testing Materials, Bulletin*, No. 164, February, 1950, pp. 28–31.) *Aero Research Technical Notes, Bulletin*, No. 105, September, 1951. 4 pp., illus. 2 references.

Test data and test procedures in studies of the effects of accelerated and natural exposure conditions on Metalite, a lightweight, high-strength sandwich material made of relatively thick end-grain balsa core to which thin facings of high-strength aluminum alloy are bonded, developed by Chance Vought and the Navy Department.

**Relative Structural Efficiencies of Flat Balsa-Core Sandwich and Stiffened-Panel Construction.** Ralph E. Hubka, Norris F.

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**The Effectiveness of Natural and Artificial Aerosols As Freezing Nuclei.** H. J. aufm Kampe and H. K. Weickmann. *Journal of Meteorology*, Vol. 8, No. 5, October, 1951, pp. 283–288, illus. 22 references.

**Weather to Order.** M. L. Kastens. *Chemical and Engineering News*, Vol. 29, No. 12, March 19, 1951, pp. 1090–1093, illus. Problems and progress in cloud seeding.

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Investigation of the properties of supercooled water droplets found in icing clouds. X-ray diffraction intensity curves were obtained for water in the temperature range 21° to −16°C. using a Bragg X-ray spectrometer.

**The Sublimation of Ice in Vacuum.** H. Kramers and S. Stemerding. *Applied Scientific Research, Section B, Electrophysics, Acoustics, Optics, Mathematical Methods*, Vol. A3, No. 1, 1951, pp. 73–82, illus. 7 references. Experiments on the rate of sublimation of ice in vacuum and at small air pressures; comparison with theory.

**Vorticity Transfer As Related to the Development of the General Circulation.** Hsiao-lan Kuo. *Journal of Meteorology*, Vol. 8, No. 5, October, 1951, pp. 307–315, illus. 13 references. Analysis of the mechanism of the development and maintenance of zonal circulation from the point of view of vorticity transfer by atmospheric disturbances.

**Large-Scale Atmospheric Exchange Processes As Diffusion Phenomena.** Robert M. White and Glenn H. Jung. *Journal of Meteorology*, Vol. 8, No. 5, October, 1951, pp. 356–358. 6 references.

**Frequency Distribution of Velocities in Turbulent Flow.** F. N. Frenkiel. *Journal of Meteorology*, Vol. 8, No. 5, October, 1951, pp. 316–320, illus. 9 references. Measurement of turbulent velocities using a conventional pressure-tube or cup anemometer.

**Averaging Processes and Reynolds Equations in Atmospheric Turbulence.** J. Kampe dé Fériet. *Journal of Meteorology*, Vol. 8, No. 5, October, 1951, pp. 358–361. 9 references.

**Discussion on "The Radar-Sonde System for the Measurement of Upper Wind and Air Data" by F. E. Jones, J. E. N. Hooper, and N. L. Adler.** *Institution of Electrical Engineers, Proceedings, Part II, Power Engineering*, Vol. 98, No. 65, October, 1951, pp. 645, 646.

**The Interpretation of Microwave Reflections from Rainfall.** David Atlas and Harold C. Banks. *Journal of Meteorology*, Vol. 8, No. 5, October, 1951, pp. 271–282, illus. 14 references.

Review of the theory of the study of rainfall patterns using microwave radar; analysis of the effects of range and rainfall attenuation as causes of distortions of the echo pattern obtained on a radar oscilloscope.

**Letters to the Editor: Tropospheric Propagation Beyond the Horizon.** J. Feinstein. *Journal of Applied Physics*, Vol. 22, No. 10, October, 1951, pp. 1292, 1293, illus. 5 references. Estimation, through a combination of wave and ray theory, of the magnitude of the field produced by the continuous partial reflections of traveling waves.

## Navigation (29)

**The Navigational Work of the C.S.I.R.O., Australia.** E. G. Bowen. *Institute of Navigation, Journal*, Vol. 4, No. 4, October, 1951, pp. 389–394, Discussion, pp. 395–398, illus. 5 references.

Summary of the researches carried out by the Radiophysics Division of the Commonwealth Scientific and Industrial Research Organization on short-range aids to navigation and on air-traffic control. The principal equipments developed for short-range navigation are the distance-measuring equipment, Multiple Track range, and a microwave direction-finding system. The air-traffic control work consisted of a detailed theoretical study of control problems and the development of simulation equipment.

**Long-Range Radar for Controlling Aircraft. I—The Operation of London Radar.** D. W. Watkins. **II—Traffic Control at the Royal Aircraft Establishment.** G. G. Harris. *Institute of Navigation, Journal*, Vol. 4, No. 4, October, 1951, pp. 402–414.

**I.** Introduction of long-range radar techniques; early experiments; operation trials and service-testing; flight experience, using the long-range radar system at London, of British European Airways; present status of the system. **II.** Types of control problems handled at the R.A.E. experimental airfields; equipment layout of the control system; extent of the control under visual and blind flying conditions.

**Radar As an Aid to Air Navigation in the Arctic.** K. R. Greenaway. *Institute of Navigation, Journal*, Vol. 4, No. 4, October, 1951, pp. 399–401, illus.

**Automatic Tracking Radar Errors.** Charles E. Brockner. *Aero Digest*, Vol. 63, No. 5, November, 1951, pp. 72, 74, 78, 80, 82, 84, 86, illus. Expressions, in terms of range and system parameters, for four sources of angular jitter in a typical conical-scanning, automatic-tracking radar.

**A Beacon Range Indicator.** J. H. McGuire. *Electronic Engineering*, Vol. 23, No. 285, November, 1951, pp. 436–439, illus. 3 references.

Proposal for a beacon range indicator that uses pulse techniques to determine the range of an aircraft by interrogating a slave beacon on the ground; general principles and make-up of the system; limitations of the system.

**Answer to the Pilot's Prayer? Trying-out the Decca Flight Log.** *Flight*, Vol. 60, No. 2233, November 9, 1951, p. 601, illus.

**The World Geographic Reference System.** William E. Johnson. *Air University Quarterly Journal*, Vol. 4, No. 4, pp. 49–57, illus. Mapping System adapted for use by the Air Force, which is a simplification of the Universal Transverse Military Grid referencing system.

## Ordnance & Armament (22)

**Aircraft Rockets.** *Interavia*, Vol. 6, No. 10, October, 1951, pp. 551–553, illus. Construction and performance of unguided and guided rocket projectiles for antiaircraft uses. Specifications of U.S. and foreign types are tabulated.

**Guided Anti-Aircraft Missiles.** *Interavia*, Vol. 6, No. 10, October, 1951, pp. 554, 555, illus. Specifications and performance data on guided antiaircraft missiles developed in the U.S. and Europe during and since World War II; effectiveness of this type of weapon.

**A General Staff Headache: Faster Speeds Demand Better Armament.** Pierre M. Gallois. *Interavia*, Vol. 6, No. 10, October, 1951, pp. 538–540, illus. 1 reference.

## Photography (26)

**A New Power Stroboscope for High-Speed Flash Photography.** W. D. Chesterman, D. R. Glegg, G. T. Peck, and A. J. Meadowcroft. (*I.E.E., Utilization Section, Paper No. 1127.*) *Institution of Electrical Engineers, Proceedings, Part II, Power Engineering*, Vol. 98, No. 65, October, 1951, pp. 619–631, Discussion, 632–634, illus. 27 references.

A stroboscope that can be used in direct photography with a drum camera or that can be synchronized with the optical compensation element of an image-compensated camera. Picture-repetition rate is from 100–4,000 pictures per sec., flash duration is 5 μsec. A hydrogen thyratron is used to trigger the tube discharge; energy is supplied to the lamp at 12 kv.

**The Performance of Image Convertors As High-Speed Shutters.** R. C. Turnock. (*I.E.E., Measurements Section, Paper No. 1178.*) *Institution of Electrical Engineers, Proceedings, Part II, Power*

*Engineering*, Vol. 98, No. 65, October, 1951, pp. 635–641, illus. 21 references. An analysis of performance at exposure durations of less than 1 μsec. of two types of image convertors used as high-speed shutters.

**Self-Adjusting Timer for Bullet Photography.** Joseph Burlock. *Review of Scientific Instruments*, Vol. 22, No. 10, October, 1951, pp. 743–745, illus. 3 references.

Circuits, characteristics, and operation of a timer that measures an interval and immediately generates an equivalent interval, for automatically timing a light source flash for photographing missiles whose velocity cannot be accurately predicted.

## Power Plants

**The Aviation Engine.** F. R. Banks. (James Clayton Lecture, February 16, 1951.) *Institution of Mechanical Engineers, Proceedings*, Vol. 162, No. 4, 1950, pp. 433–445. 4 references. Aviation engine development and progress during the last two decades.

**Power Politics.** F. Rodwell Banks. *The Aeroplane*, Vol. 81, No. 2101, October 26, 1951, pp. 550, 551, illus. Problems and developments in the production of engines for high-performance aircraft.

### JET & TURBINE (5)

**The Gas Turbine in Perspective.** Hayne Constant. *Institution of Mechanical Engineers, Proceedings*, Vol. 163, *War Emergency Proceedings No. 60, Lectures on Internal Combustion Turbines*, 1950, pp. 183–192, illus. A survey of the progress that has been achieved in Britain over the last decade in improving the performance of gas-turbine components.

**The French Aircraft Gas Turbine Industry.** Paul H. Wilkinson. *Aviation Age*, Vol. 16, No. 5, November, 1951, pp. 42, 43, illus. Tooling and production in French jet-engine factories.

**Overall and Stage Characteristics of Axial-Flow Compressors.** A. R. Howell and R. P. Bonham. *Institution of Mechanical Engineers, Proceedings*, Vol. 163, *War Emergency Proceedings No. 60, Lectures on Internal Combustion Turbines*, 1950, pp. 235–258, illus. 15 references.

**The Cooled Gas Turbine.** A. G. Smith and R. D. Pearson. *Institution of Mechanical Engineers, Proceedings*, Vol. 163, *War Emergency Proceedings No. 60, Lectures on Internal Combustion Turbines*, 1950, pp. 221–234, illus. 15 references. Review of possible methods of applying gas and liquid cooling to turbine blades; experimental and theoretical data.

**Performance Index; Assessment of an Italian Suggestion for a New Unit of Power for Turbojets.** *Flight*, Vol. 60, No. 2230, October 19, 1951, pp. 507, 508, illus.

### RAM-JET & PULSE-JET

**Burners for Supersonic Ram-Jets; Factors Controlling Over-All Burner Performance.** James W. Mullen, II, John B. Fenn, and Roland C. Garmon. *Industrial and Engineering Chemistry*, Vol. 43, No. 1, January, 1951, pp. 195–211, illus. 41 references. Results of experiments on the influence of air-fuel ratio, mixture condition, igniter geometry, inlet air temperature, combustion chamber length, and air mass flow on burner efficiency.

### RECIPROCATING (6)

**Aircooled Lightweight Diesel for Aircraft.** *Automotive Industries*, Vol. 105, No. 10, November 15, 1951, p. 80, illus.

Specifications of a lightweight, air-cooled aircraft diesel engine built by Diesel Power, Inc., Pittsburgh. The engine was flight-tested in a Taylorcraft airplane built to Army specifications for liaison aircraft.

**The Supercharging of Internal-Combustion Engines.** Harry R. Ricardo. *Institution of Mechanical Engineers, Proceedings* Vol. 162, No. 4, 1950, pp. 421–428, illus.

### ROCKET (4)

**Chemical Kinetics and Rocket Nozzle Design.** F. J. Krieger. *American Rocket Society, Journal*, Vol. 21, No. 6, November, 1951, pp. 179–185, illus. 7 references.

Investigation of the effect of chemical kinetics on rocket nozzle design for the case of hydrogen gas flowing adiabatically through a rocket nozzle having a chamber-to-throat area ratio of 2 to 1. Chamber velocity, nozzle throat area, nozzle length, and jet velocity (equivalent specific impulse) were determined for constant composition flow, instantaneous chemical equilibrium flow, and kinetic chemical equilibrium flow.

**Aspects of Combustion Stability in Liquid Propellant Rocket Motors. I—Fundamentals; Low-Frequency Instability with Monopropellants.** L. Crocco. *American Rocket Society, Journal*, Vol. 21, No. 6, November, 1951, pp. 163–178, illus. 6 references.

Explanation of time lag; formulation of a correlation between the time lag and the pressure history during the time lag for the case of oscillating pressures; determination of the critical conditions for oscillating pressures. The relationship between instability and injection rate for rockets with constant rate-supply propellant systems and rockets with constant pressure-supply propellant systems is examined, along with the effects of injection rate on the critical conditions and the nonuniform time lag for different portions of the propellant.

## Production (36)

**The Booming West Coast Aircraft Industry.** R. Raymond Kay. *Automotive Industries*, Vol. 105, No. 10, November 15, 1951, pp. 42–47, 102, 104, 106, 108, illus.

Expansion programs of Boeing, Convair, Douglas, Hiller Helicopters, Lockheed, North American, Northrop, and Ryan aviation manufacturing companies; location, facilities, and tabulation of aircraft produced by each company; values of sales and unfilled orders.

**Assembly-Fixture Practice; Profile-Control Subassembly and Boxing-Up Equipment for the Bristol Britannia (Type 175) Aircraft.** *Aircraft Production*, Vol. 13, No. 157, November, 1951, pp. 341–347, illus.

**Some Problems in the Manufacture of Experimental Gas Turbines.** L. H. Leedham. *Institution of Mechanical Engineers, Proceedings*, Vol. 163, *War Emergency Proceedings No. 61, Industrial Administration and Engineering Production*, 1950, pp. 281–290, Discussion, pp. 290–293, illus. 1 reference.

General manufacturing problems caused by the need for special materials, complexity of components, and small number of units required; development of special tools and methods, blade profiling apparatus, and inspection techniques.

**The French Aircraft Gas Turbine Industry.** Paul H. Wilkinson. *Aviation Age*, Vol. 16, No. 5, November, 1951, pp. 42, 43, illus. Tooling and production in French jet-engine factories.

**Metal Stitching Speeds Assembly, Reduces Cost. I.** Arthur G. Denne. *Tool Engineer*, Vol. 27, No. 5, November, 1951, pp. 40–42, illus.

**Statistical Quality Control of Metalworking Operations. III.** Lester F. Spencer. *Steel Processing*, Vol. 37, No. 10, October, 1951, pp. 506–508, illus.

**Investment Casting: Alloy Selection and Design.** D. V. Ludwig and R. L. Wood. *Product Engineering*, Vol. 22, No. 11, November, 1951, pp. 184–190, illus.

**Stretch-Forming.** G. B. Evans. *Aircraft Production*, Vol. 13, No. 157, November, 1951, pp. 332–334, illus. 11 references. Properties achieved in heat-treatable and nonheat-treatable alloys through stretch-forming; advantages and disadvantages of annealing and solution treatment.

**Stretch-Wrap Forming Important at Canadair.** *Canadian Aviation*, Vol. 24, No. 11, November, 1951, pp. 105, 106, illus. Performance and applications of Canadair's Hufford Stretch-Wrap Former.

**What To Do About Wrinkled Stampings.** Thomas A. Dickinson. *Steel Processing*, Vol. 37, No. 10, October, 1951, pp. 499, 500, 533, illus. Development at North American Aviation, Inc. of a clip that equalizes forming pressures and of a pneumatic hammer and a pneumatic slapper that decrease time spent in dewrinkling.

**Improved Producibility Through Extrusion.** *Machine Design*, Vol. 23, No. 11, November, 1951, pp. 139–141, illus. A mass-production method for hot extrusion of one-piece, hollow steel propeller blades developed by Curtiss-Wright and the Air Force.

**Navy Designs Special Mill for Airfoil Contour.** Abraham Schwartz. *Applied Hydraulics*, Vol. 4, No. 11, November, 1951, pp. 63, 64, 88, 89, illus. Structure and operation of an hydraulic milling machine for airfoil contour designs, with an allowable tolerance measurable in thousandths of an inch.

**Method X Machines Superalloys.** *Aviation Age*, Vol. 16, No. 5, November, 1951, p. 43, illus.

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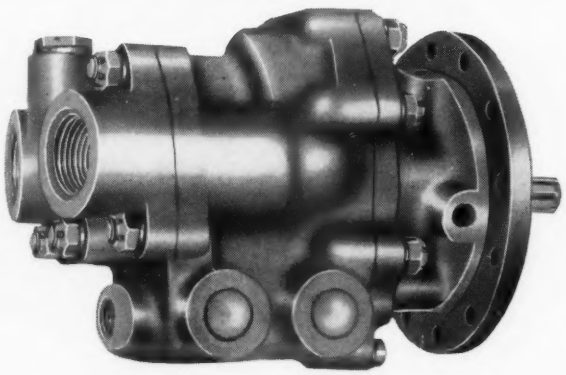
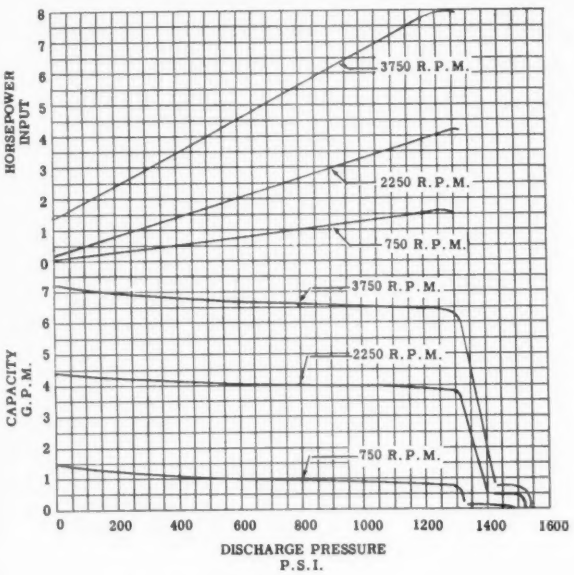


Capacity: 2 g. p. m. @ 1500 r. p. m. @ 1250 p. s. i. Maximum operating pressure 1500 p. s. i. Weight: 8.9 lbs. approx.

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**Undercarriage Manufacture.** *Aircraft Production*, Vol. 13, No. 157, November, 1951, pp. 350–355, illus. Production methods and tooling for the oleo-leg for Vickers-Supermarine Attacker.

**Some Notes on Semi-Tubular Rivets and Riveting.** V. W. Clarkson. *The Technical Instructor*, Vol. 6, No. 9, September, 1951, pp. 7–10, illus. Riveting methods and applications of drilled tubular rivets.

**British Experience in the Argon Arc Welding of Aluminium.** W. V. Binstead and E. G. West. (*International Welding Congress, Oxford, England*, July, 1951.) *Institute of Welding, Transactions*, Vol. 14, No. 4, August, 1951, pp. 121–139, illus. 34 references.

**Recent Advances in the Technique of Electric Spot Welding of Aluminium Alloys in the French Aircraft Industry.** J. Faguet. (*International Welding Congress, Oxford, England*, July, 1951.) *Institute of Welding, Transactions*, Vol. 14, No. 4, August, 1951, pp. 110–120, illus.

**Recent French Studies on the Weldability of Aluminium Magnesium Alloys.** H. Granjon. (*International Welding Congress, Oxford, England*, July, 1951.) *Institute of Welding, Transactions*, Vol. 14, No. 4, August, 1951, pp. 140–144, illus. 6 references. General problem of the weldability of the aluminum-magnesium alloys; phenomenon of blistering; crack sensitivity of welds in aluminum-magnesium alloys.

**The Brabazon Assembly Plant.** *Engineering Journal*, Vol. 34, No. 10, October, 1951, pp. 982–984, illus. Main structural details of the Brabazon assembly hanger at Filton near Bristol.

**Canberras Under Construction.** Norman Macmillan. *Aeronautics*, Vol. 25, No. 4, November, 1951, pp. 62, 65, 68, illus. Lofting practices and construction techniques used in building the English Electric Canberra; equipment for flight testing.

## Propellers (11)

**A Method for Predicting the Upwash Angles Induced at the Propeller Plane of a Combination of Bodies with an Unswept Wing.** Paul F. Yaggy. *U.S., N.A.C.A., Technical Note No. 2528*, October, 1951. 24 pp., illus. 6 references. Development of an approximate method for predicting the upwash angles induced at the horizontal centerline of the propeller disc of a twin-engine airplane; application to other airplanes.

**Improved Productibility Through Extrusion.** *Machine Design*, Vol. 23, No. 11, November, 1951, pp 139–141, illus. A mass-production method for hot extrusion of one-piece, hollow steel propeller blades developed by Curtiss-Wright and the Air Force.

## Rotating Wing Aircraft (34)

**The Helicopter in Combat.** Edward L. Barker. *United States Naval Institute, Proceedings*, Vol. 77, No. 11, November, 1951, pp. 1207–1221, illus. Tactical uses of helicopters.

## Sciences, General (33)

### MATHEMATICS

**Precise Solutions of Linear Simultaneous Equations Using a Low Cost Analog.** Sumner Ackerman. *Review of Scientific Instruments*, Vol. 22, No. 10, October, 1951.

Design, circuits, and principles of operation of a low cost analog computer that, when used in conjunction with techniques that can be handled by standard desk calculators, can solve systems of linear simultaneous equations to any degree of accuracy.

**An Introduction to Computer Concepts. III.** John D. Goodell. *Radio & Television News*, Vol. 46, No. 4, October, 1951, *Radio-Electronic Engineering*, pp. 14–16, illus. Digital and analog computers; comparison of computing mechanisms with the human mind.

**Analog Computers Solve Complex Problems.** Louis L. Grandi and Don Lebell. *Radio & Television News*, Vol. 46, No. 5, November, 1951, pp. 70, 71, 138, 139, illus. Analog computer types and their uses in the computing laboratory of the University of California engineering department.

**A Magnetic Tape "Memory" for SEAC.** *U.S., National Bureau of Standards, Technical News Bulletin*, Vol. 35, No. 11, November, 1951, pp. 161–163, illus. 2 references. A computer-controlled external auxiliary memory that uses a magnetic tape recording medium; it combines high-speed starting, stopping, and reversing with mechanical simplicity.

**Evaluation of Automatic Computing Machines.** Franz Alt. *Product Engineering*, Vol. 22, No. 11, November, 1951, pp. 146–152, illus. Comparison of the performance and method of operation, accuracy, and speed of analog and digital computers.

**Computing Machines in Chemical Engineering.** (*American Chemical Society, Division of Industrial and Engineering Chemistry, Symposium, Boston*, 1951.) *Industrial and Engineering Chemistry*, Vol. 43, No. 11, November, 1951, pp. 2441–2486, illus. 91 references.

**On a Relaxation Method for Eigenvalue Problems.** Stephen H. Crandall. *Journal of Mathematics and Physics*, Vol. 30, No. 3, October, 1951, pp. 140–145. 4 references.

**Differential Equations and Their Characteristics.** G. N. Patterson. *Toronto, University, Institute of Aerophysics, Review No. 1*, October, 1950. 28 pp., illus.

**Graphical Differentiation.** J. M. Ramrath. *Allis-Chalmers Electrical Review*, Vol. 16, No. 3, Third Quarter, 1951, pp. 28, 29, illus. A graphic method that employs a surface mirror for evaluating nonlinear displacement performance curves. The method is useful when no mathematical formula is available.

**Poiseuille Functions.** H. A. Lauwerier. *Applied Scientific Research, Section B, Electrophysics, Acoustics, Optics, Mathematical Methods*, Vol. A3, No. 1, 1951, pp. 58–72, illus. 2 references. A detailed study of the Whittaker functions occurring in problems connected with Poiseuille flow in cylindrical tubes.

**On the Absolute Cesàro Summability of Integrals.** D. Borwein. *London Mathematical Society, Proceedings*, Vol. 1 (Series 3), No. 3, September, 1951, pp. 308–326. 9 references.

**Direct Products of Banach Spaces and Linear Functional Equations.** A. F. Ruston. *London Mathematical Society, Proceedings*, Vol. 1 (Series 3), No. 3, September, 1951, pp. 327–384. 25 references. Extensions of the Fredholm theory integral equations with operators in the trace class of a real or complex Banach space.

**A Graphical Method for Plotting Amplitude and Phase Angle of Transfer Functions of Dynamic Systems Without Factoring Polynomials.** Earl F. Smith. *U.S., N.A.C.A., Technical Note No. 2522*, November, 1951. 35 pp., illus. 1 reference.

**Construction of Circular Nomographs with Hyperbolic Coordinates.** Walter Herbert Burrows. *Industrial and Engineering Chemistry*, Vol. 43, No. 1, January, 1951, pp. 158, 159, illus. 3 references.

**Simplified Mathematical Forms for Engineering Use.** Ralph H. Upson. *Aeronautical Engineering Review*, Vol. 11, No. 2, February, 1952, pp. 35–38, illus. 7 references. Examples of simple approximate linear and geometric equations useful for engineering problems.

**Simplified Statistics for Small Numbers of Observations.** R. B. Dean and W. J. Dixon. *Analytical Chemistry*, Vol. 23, No. 4, April, 1951, pp. 636–638, illus. 18 references. Time-saving methods of computation for ten or fewer observations; table of efficiencies and conversion factors for two to ten observations.

**Chi-Square Test.** Wayne A. Ring and Edward C. Varnum. *Machine Design*, Vol. 23, No. 11, November, 1951, pp. 115–117, illus. 1 reference. For checking machine performance.

## Space Travel

**Artificial Satellites Explained; The Space-Station Project: What It Is and How It Might Work.** V. A. Firsoff. *Flight*, Vol. 60, No. 2230, October 19, 1951, pp. 504–508, illus.

## Structures (7)

**A Theoretical Investigation of Roll Flattening.** D. R. Bland. *Institution of Mechanical Engineers, Proceedings*, Vol. 163, *War Emergency Proceedings No. 58, Applied Mechanics*, 1950, pp. 141–144, Discussion, pp. 144–148, illus. 5 references. A method of estimating the distortion of the roll surface when subject to a known pressure distribution; comparison with the results of Hitchcock's solution.

**Bending Stresses in Eccentric Curved Beams.** Joseph P. Vidosic. *Product Engineering*, Vol. 22, No. 11, November, 1951, pp. 180–183, illus. Graphic and analytic data that can be used to

calculate accurately stresses in arch and crescent type eccentric beams.

**Secondary Stresses in Thin-Walled Beams with Closed Cross Sections.** Stanley Urner Benscoter. *U.S., N.A.C.A., Technical Note No. 2529*, October, 1951. 104 pp., illus. 19 references.

Development of an accurate method of determining secondary stresses in thin-walled, uniform beams of closed cross sections; formulation and solution of the integrodifferential equation governing axial displacements for a beam without longitudinal stiffeners, and the corresponding summation-difference equation for a beam with stiffeners.

**Readers' Forum: Parameters Predicting Failure of Partial Diagonal Tension Beams.** Bertram Klein. *Journal of the Aeronautical Sciences*, Vol. 19, No. 2, February, 1952, pp. 141, 142, illus. 8 references. Parameters for web failure and for the forced crippling of single, bent-up uprights.

**A Study of an Analogous Model Giving the Nonlinear Characteristics in the Buckling Theory of Sandwich Cylinders.** Chi-Teh Wang and G. V. R. Rao. *Journal of the Aeronautical Sciences*, Vol. 19, No. 2, February, 1952, pp. 93–100, illus. 10 references.

A qualitative study of the effect of shear rigidity of the core of a sandwich cylinder on the nonlinear characteristics of the buckling phenomenon, based on an analysis of the buckling of sandwich columns supported on sandwich rings. For finite deflections, the rings behave as nonlinear springs.

**Stresses in a Two-Bay Noncircular Cylinder Under Transverse Loads.** George E. Griffith. *U.S., N.A.C.A., Technical Note No. 2512*, October, 1951. 34 pp., illus. 11 references.

Development of a method, based on a general eighth-order differential equation and including flexibility effects, for the solution of the stresses in a two-bay noncircular cylinder under transverse loads.

**Fuselage Cutout Analysis.** W. L. Vaughan. *Aero Digest*, Vol. 63, No. 5, November, 1951, pp. 42, 44, 46, 50, illus. 4 references. A method that provides complete shear distribution on fuselage cross sections by including loads in the longitudinal boundary sills.

**An Experimental Investigation of Plastic Stress-Strain Relations.** J. L. M. Morrison and W. M. Shepherd. *Institution of Mechanical Engineers, Proceedings*, Vol. 163, *War Emergency Proceedings No. 55, Applied Mechanics*, 1949, pp. 1–9, Discussion, pp. 10–17, illus.

Tests carried out on a steel and on an aluminum alloy, with the object of discriminating between and assessing the merits of the incremental and total plastic strain theories in the region where the elastic and plastic strains are of comparable magnitude.

## Thermodynamics (18)

**An Investigation of Aircraft Heaters. XXXVIII—Determination of Thermal Performance of Rectangular- and Trapezoidal-Shaped Inner-Skin Passages for Anti-Icing Systems.** L. M. K. Boelter, V. D. Sanders, and F. E. Romie. *U.S., N.A.C.A., Technical Note No. 2524*, November, 1951. 21 pp., illus. 10 references.

**Flame Propagation. II—The Determination of Fundamental Burning Velocities of Hydrocarbons by a Revised Tube Method.** Melvin Gerstein, Oscar Levine, and Edgar L. Wong. **III—Theoretical Consideration of the Burning Velocities of Hydrocarbons.** Dorothy Martin Simon. **IV—Correlation of Maximum Fundamental Flame Velocity with Hydrocarbon Structure.** R. R. Hibbard and B. Pinkel. *American Chemical Society, Journal*, Vol. 73, Nos. 1, 4, January, April, 1951, pp. 418–422; 422–425; 1622–1625, illus. 23 references.

**Explosibility of Mixtures of Propane, Air, and Carbon Dioxide and of Propane, Air, and Nitrogen at Elevated Pressures.** R. E. Kennedy, I. Spolan, and G. S. Scott. *U.S., Department of the Interior, Bureau of Mines, Report of Investigations No. 4812*, August, 1951. 15 pp., illus., tables. 9 references.

**The Thermodynamic Properties of Naphthalene.** Gordon M. Barrow and A. L. McClellan. *American Chemical Society, Journal*, Vol. 73, No. 2, February, 1951, pp. 573–575. 20 references.

## Water-Borne Aircraft (21)

**Hydrodynamic Investigation of Series of Hull Models Suitable for Small Flying Boats and Amphibians.** W. C. Hugli, Jr., and

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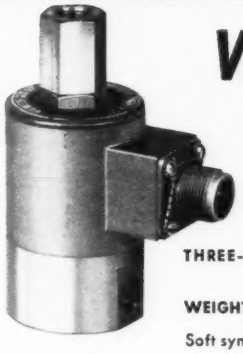
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W. C. Axt. *U.S., N.A.C.A., Technical Note No. 2503*, November, 1951. 122 pp., illus. 25 references.

An investigation at the Experimental Towing Tank, Stevens Institute of Technology, to determine the hydrodynamic characteristics of a series of hull models suitable for small flying boats or amphibians of 2,000 to 5,000 lbs. gross weight.

**Largest Flying Boat Nearly Completed in England.** W. F. Bradley. *Automotive Industries*, Vol. 105, No. 7, October 1, 1951, pp. 40, 41, 116, 120, illus. Specifications and construction of the Saunders-Roe Princess.

**The (Saunders-Roe) Princess Flying Boat.** *The Engineer*, Vol. 192, No. 4998, November 9, 1951, p. 589, illus. Special equipment for transferring the aircraft from assembly hangar to hangar apron and for lowering it into the water for flight trials.

## Wind Tunnels & Research Facilities

**NACA Seeks Answers to Mach 3.5 Speeds.** Irving Stone. *Aviation Week*, Vol. 55, No. 20, November 12, 1951, pp. 20–22, 24, 27, 28, illus.

Wind tunnels and test cells at N.A.C.A.'s Lewis Flight Propulsion Laboratory for jet-engine research; specialized instruments for recording high temperatures and thrusts; data reduction system.

**NACA Reveals Progress in Propulsion.** Robert McLarren. *Aero Digest*, Vol. 63, No. 5, November, 1951, pp. 60, 62–64, 66, 69, illus. Equipment, facilities, and research program at N.A.C.A.'s Lewis Flight Propulsion Laboratory.

**Wright Air Development Center.** H. S. Fisher, Jr. *Ordnance*, Vol. 36, No. 189, November-December, 1951, pp. 401, 402, illus. Laboratories of Wright Air Development Center at Wright-Patterson Air Force Base, Dayton.

**USAF's Missile Test Center. I.** *Aviation Age*, Vol. 16, No. 5, November, 1951, pp. 35–37, illus. Facilities for launching and instrument testing at U.S.A.F. Missile Test Center.

**Current Projects in Aerodynamics Laboratory, Aircraft and Allied Instrument Laboratory, Engine Laboratory, Engineering Section, Flight Research Section, Fuels and Lubricants Laboratory, Gas Dynamics Section, Low Temperature Laboratory, and Structures Laboratory.** *Canada, National Aeronautical Establishment, Quarterly Bulletin, Report No. NAE 1951 (3)*, July 1–September 30, 1951, pp. 6–25, illus.

**Some Fluid Dynamic Research Techniques.** A. D. S. Carter, S. J. Andrews, and H. Shaw. *Institution of Mechanical Engineers, Proceedings*, Vol. 163, *War Emergency Proceedings No. 60, Lectures on Internal Combustion Turbines*, 1950, pp. 249–263, illus. 13 references.

Design, operation, and basic principles of the simple cascade tunnel, heat-transfer tunnel, icing tunnel, and annular tunnel, for investigating internal combustion problems; ducting research; general instrumentation and measurement techniques, boundary-layer investigation; high-speed flow visualization.

**Starting Processes in an Intermittent Supersonic Wind Tunnel.** G. V. Bull. *Toronto, University, Institute of Aerophysics, Report No. 12*, February, 1951. 48 pp., illus. 9 references.

Theoretical and experimental analyses of the nonstationary and quasi-steady flow phenomena associated with the setting up of a gradient-free supersonic air stream in an intermittent-type wind tunnel. A 5- by 5-cm. shock tube was used for the tests, and the theoretical analysis is verified by shadowgraph and schlieren photographs that show the time history of the starting processes.

**Investigations on Wings with and Without Sweepback at High Subsonic Speeds.** Jakob Ackeret, Max Degen, and Nikolaus Rott. (*Zeitschrift für Angewandte Mathematik und Physik*, Vol. 1, 1950.) *U.S., N.A.C.A., Technical Memorandum No. 1320*, November, 1951. 14 pp., illus. 4 references.

Investigation in the high-speed wind tunnel of the Institut für Aerodynamik, Eidgenössische Technische Hochschule, Zurich; results checked against theoretical tunnel correction formulas; extrapolation to vanishing tunnel influence.

**Letters to the Editor: A New Method for the Production of Air Shocks in a Tube.** A. B. Laponsky and R. J. Emrich. *Journal of Applied Physics*, Vol. 22, No. 10, October, 1951, p. 1297. 2 references. Generation of a transient flow, in which flow variables change over measurable distances and times, by accelerating a relatively large piston at one end of a gas-filled tube.

**Readers' Forum: A Note on the Design of Supersonic Wind-Tunnel Nozzles.** R. E. Meyer. *Journal of the Aeronautical Sciences*, Vol. 19, No. 2, February, 1952, pp. 140, 141. 3 references.

**Peenemünde's Super-Sonic Wind Tunnel.** Werner Kraus. *Interavia*, Vol. 6, No. 10, October, 1951, pp. 558–561, illus.

Brief account of the research methods used for supersonic studies at Peenemünde Research Center up to 1945; design details of the open free-flow supersonic tunnel for intermittent operation; auxiliary equipment and instrumentation; operation of the 30-ft. schlieren camera.

**New Jet Tester Speeds Overhaul.** *Aviation Week*, Vol. 55, No. 20, November 12, 1951, pp. 50, 52, 54, illus. Low-cost, demountable test cell, developed by Janke and Co., Inc., for trouble-shooting and overhaul testing of J-33, -35, and -47 jet engines.

# I.A.S. News

(*Continued from page 80*)

**Spencer, Ralph I.,** B.S. (Aero.), Jr. Engineer, Design Operations Section, Chance Vought Aircraft Div., United Aircraft Corp.

**Stone, Charles R.,** B. of Ae.E., Aerodynamicist "A," Boeing Airplane Co. (Seattle).

**Thome, Pitt G.,** B.S. in Ae.E., Ensign, U.S.N.; Communications Officer, U.S.S. "Stoddard" (DD-566).

**Thumser, Louis F., Jr.,** Captain, U.S.A.F.; Project Officer, ADC, Wright-Patterson Air Force Base.

**Tyler, Fielden B.,** B. of Ae.E., Design Engineer, AGT Engineering Div., General Electric Co.

**Viscovitz, John J., Jr.,** B.S. in Ae.E., Assigned to Production Engineering Dept., Goodyear Aircraft Corp.

**Wade, John H. T.,** B.A.Sc., Research Asst., Institute of Aerophysics, University of Toronto.

**Welton, Ralph E., Jr.,** B.S. in Air Transportation, Technical Writer, Service Engineering Dept., Consolidated Vultee Aircraft Corp. (Ft. Worth).

**Werschmidt, Edgar C.,** B. of Ae.E., Engineering Draftsman "B," Georgia Div., Lockheed Aircraft Corp.

**Wilson, Jesus.**

**Wolfe, Donald H.,** B.S. in Ae.E., Major, U.S.A.F.; Asst. Prof. of Air Science & Tactics, Indiana University.

**Young, Joseph P.,** B.S., Stress Analyst "C," North American Aviation, Inc. (Downey).

**Zach, Theodore A.,** B. of Ae.E., Design Aero. Engineer, Naval Air Development Center (Johnsville).

**Zimmet, Donald,** B. of Ae.E., Test Engineer—Stress Analyst, Advance Design & Development Div., Wright Aero. Div., Curtiss-Wright Corp.

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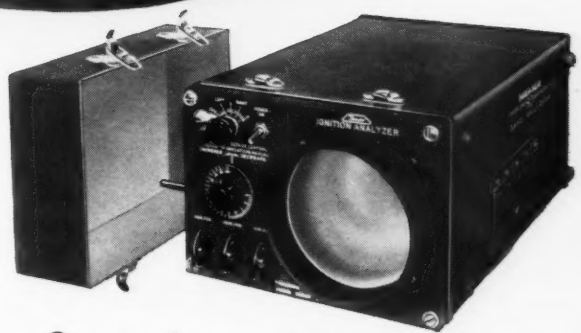

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# Aeronautical Reviews — BOOKS

### Écoulements des Fluides Compressibles

**By R. Sauer. Paris and Liége, Librairie Polytechnique Ch. Beranger, 1951. 307 pp., figs. 3,900 fr.**

Professor Robert Sauer is known to most aerodynamicists as the author of the first comprehensive textbook dealing with mechanics of compressible fluids. His *Introduction to Theoretical Gas Dynamics*, first published in 1943 in German and since translated into English and other languages, remained practically the only textbook in its field until about 1947, when other works on compressible fluid mechanics, mostly by American authors, began to appear.

Professor Sauer's latest treatise is based on the manuscript of his lectures on unsteady gas dynamics, which was written in 1945–1946 and which can be regarded as the development of his earlier *Introduction*. In *Écoulements des Fluides Compressibles*, we find a unified and concise treatment of steady and unsteady flows of compressible fluids in the absence of boundary layers. The scope and arrangement of subject matter are indicated by the outline of the contents which follows.

In chapter 1 on fundamental concepts, basic dynamic and thermodynamic relations for inviscid fluids and equations of steady and unsteady motion with two independent variables are given. Analogies between steady and unsteady flow theories are discussed.

The second chapter is devoted to linearized steady and unsteady flows and includes such topics as the method of small perturbations, the Prandtl-Glauert rule, subsonic and supersonic linearized flow about airfoils and slender bodies, and linearized plane, cylindric, and spheric wave motion.

Chapter 3 is on the exact theory of steady supersonic flows and continuous waves of large amplitude. Here are covered the Prandtl-Meyer flow and the method of characteristics for two-dimensional and rotationally symmetric steady flow and for unsteady flow in ducts of constant and variable cross section with entropy changes. Special cases of flow of gas with $\gamma = \pm 1$ and $\gamma = 3$ are discussed. The last section of this chapter deals with Legendre and Molenbroek transformations.

The exposition of methods of application of the theory of characteristics is continued in the fourth chapter, which is mainly taken up with the mathematical theory of characteristics of systems of the first order and partial differential equations.

The fifth chapter deals with the exact theory of steady subsonic flows and includes the following topics: power series development for transonic flow in nozzles and of potential and stream functions; methods of successive approximations; Taylor's electrical analogy; and hodograph methods.

Flows involving shock waves are covered by the last two chapters. The sixth chapter, on fundamental laws of shock waves, discusses limit lines, normal and oblique shocks, shock polars, and detonation and deflagration waves. The last chapter, which is concerned with shock waves in steady and unsteady flows, deals with formation, reflection, and superposition of weak shocks; reflection and interaction of plane shocks; examples of flows involving plane shocks; supersonic flow about unyawed circular cones and hodograph for conical flow; Busemann's approximation for airfoils; and plane and spherical explosion waves.

As is evident from the above summary, the steady and unsteady flow theories are developed in parallel throughout the text, and approximate methods of solution, both analytic and numeric-graphic, are emphasized. In spite of the purely theoretic character of the book, the relationship of mathematical theory to physical phenomena is always kept in sight. Adequate, but not too numerous, references are made to original papers that mark the development and advance of compressible flow theory.

It was the author's intention to give a solid theoretic background in the theory of compressible flows rather than to deal with the theoretic aspects of engineering aerodynamics. Accordingly, reference must be made to other sources for information on the aerodynamics and performance of wings and control surfaces and on the correlation of theory with experiments.

Although Professor Sauer's book was originally written in German, this, the first edition, is an excellent translation into French by Carrière. Each chapter is preceded by a short summary, but unfortunately no subject or author index is available. A uniform, standard German notation is employed throughout the text, but in computing numerical tables for flow of air two values of $\gamma$ (1.405 and 1.4) are used on different occasions. Altogether, three tables are included which cover isentropic flow, Prandtl-Meyer expansion, and normal shock.

Professor Sauer's book is an important and welcome addition to the growing literature of compressible flow. It will serve a useful purpose both as a textbook of advanced fluid mechanics and as a reference work to be consulted by scientists as well as engineers.

JULIUS LUKASIEWICZ
Assistant Research Officer
National Research Council
Ottawa, Canada

**For information on I.A.S. Library Service Facilities, see page 83**

Statements and opinions expressed in Book Reviews are to be understood as individual expressions and not necessarily those of the Institute.

## Book Notes

### AERODYNAMICS

**Fluid Mechanics.** Victor L. Streeter. New York, McGraw-Hill Book Company, Inc., 1951. 366 pp., illus., diagrs., figs. $5.00.

This text on elementary fluid mechanics is intended for students who have completed integral calculus and at least two courses in engineering mechanics. In general, partial differentials have not been used in order to simplify the treatment and to focus the student's attention on fluid phenomena. At the outset, statics are considered; this discussion is followed by an introduction to the concepts, basic definitions, and equations for fluid motion. Fluid properties are introduced as needed and are treated briefly in an appendix. Chapter 3 is required before any of the following chapters, but the order of study of Chapters 4 to 9 is relatively unimportant. The author anticipates that material will be chosen in line with the interest of the student groups. Chapter 8, for ex-

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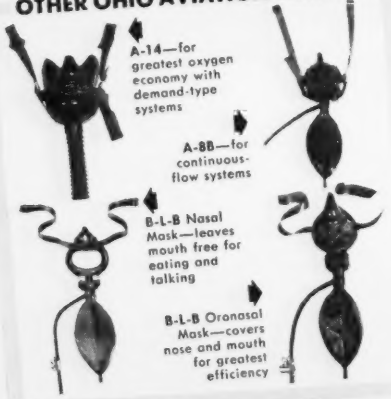
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ample, is primarily for civil engineering students, Chapter 9 for aeronautical engineering students, and Chapter 10 for mechanical engineering students. Illustrative problems are numerous, and references are listed toward the end of each chapter. The usual type of numerical problem is given at the end of each chapter, followed by objective problems of the multiple-choice type. The author is Research Professor in Mechanics and Director of Fundamental Fluids Research, Illinois Institute of Technology, and Consultant in Mechanics to the Armour Research Foundation.

Contents: Chapter 1, Pressure Intensity. Chapter 2, Static Pressure Forces. Chapter 3, Fluid-Flow Concepts and Basic Equations. Chapter 4, Action of Fluid Jets—Turbomachinery. Chapter 5, Laminar Flow. Chapter 6, Flow Measurement. Chapter 7, Steady Flow in Closed Conduits. Chapter 8, Flow in Open Channels. Chapter 9, Flow Around Immersed Bodies. Chapter 10, Oil Hydraulic Systems. Appendix A, Physical Properties of Fluids. Appendix B, Partial Derivatives and Total Differentials.

## AIRPORTS

**The Aviation Week Airport Directory, 1951.** 19th Ed. New York, McGraw-Hill Publishing Company, Inc., 1951. 250 pp., illus., maps, $3.00.

More than 6,000 U.S. civil and military airports are listed and described in this edition. The data were obtained from individual questionnaires and have been checked against C.A.A. records. Contents: How To Read and Interpret Airport and Seaplane Base Descriptions. Abbreviations. CAA-Regional and District Offices. Map of CAA Regions and Regional Offices. Municipal Aviation Officials. American Association of Airport Executives. U.S. Weather Bureau Offices. International Aviation Vocabulary. Airway Radio Communications—Aeronautical Facility Identifications. United States and Canadian Certificated Airlines. State Taxes Levied on Aviation Gasoline. State Aviation Motor Fuel Taxes, Refunds, and Exemptions. Airport Directory State Listings. Seaplane Facilities. State Aviation Boards and Commissions. Aviation Distributors and Manufacturers Association. Official Ground to Air Emergency Code Distress Signals.

## FUELS & LUBRICANTS

**Bearing Lubrication.** London, C. C. Wakefield & Company Limited, 1951. 134 pp., illus., diagrs., figs.

*Bearing Lubrication*, written by the staff of the Wakefield Company, makers of lubricants and lubrication devices, is intended as a guide to good bearing operation. It covers a wider field than is indicated by its title. Fitting of bearings and the properties of bearing materials and lubricants are treated in considerable detail. The types of bearings under discussion include those used in various kinds of machinery and those found in internal-combustion engines ranging from small, low-powered engines to larger engines for vehicles and stationary plant. The emphasis is on the practical side, but much theoretical material on bearing design and analysis is presented. Diagrams, some printed in contrasting colors, of actual equipment are found on almost every page. Tables and charts of engineering data, as well as stress and load formulas, are numerous. A detailed table of contents and a detailed index of subjects simplify use of the book as a reference work and handbook for trouble-shooting.

Contents: Friction and Lubrication. Lubricants: Their Properties and Deterioration in Service. Bearing Loads. Plain Bearings. Plain Bearing Total Loss Lubrication Systems. Grease Lubrication for Plain Bearings. Oil Circulating Systems. Ball and Roller Bearings. Vertical Spindles, Vertical Slides, and Plain Thrust Bearings. Oil and Grease Sealing Devices. Lubricating System and Bearing Troubles.

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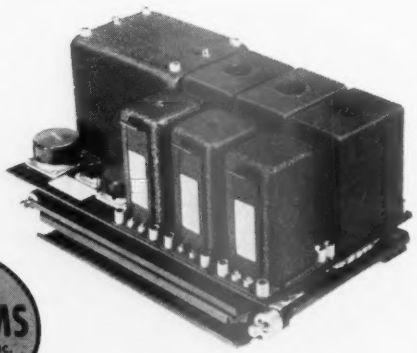

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Fort Lauderdale, Fla. POST & STEWART AVENUES, WESTBURY, N.Y. El Segundo, Cal.


York, Random House, 1951. 60 pp., illus., diagrs. $1.00.

A popular account of the evolution of rockets and rocket motors. The text covers early rocket history, the major developments of World War II, and American experiments since the war. The final chapter is devoted to the problems of a voyage to the moon, orbital stations, and space travel in general. Principles are explained in simple terms, and the author's style makes for easy reading. The book is illustrated with more than 75 colored and black-and-white sketches. Willy Ley has written the foreword.

### INSTRUMENTS

**Modern Pyrometry.** Charles H. Campbell. New York, Chemical Publishing Company, Inc., 1951. 150 pp., figs. $4.00.

An introduction to the principles of pyrometry and a survey of common and new methods of temperature measurement and control for metallurgical processes. The author, who is a research engineer in the Research Laboratory of the American Steel & Wire Company, has developed this book from a lecture delivered in 1947 before the Cleveland Chapter of the American Society for Metals. In the first chapter, types and uses of thermocouples, lead wire, and protection tubes, thermoelectric effects, requirements and types of thermocouples, calibration, types and insulation of lead wire, protection tubes, and high-temperature thermocouples are discussed. Indicators of the millivoltmeter and potentiometer types, electronic balancing mechanisms, automatic recording, and temperature control and program control are treated in Chapter 2. In Chapter 3, Other Methods of Temperature Measurement and Control, attention is given to resistance thermometers (mercury and bimetallic systems), radiation pyrometers, photoelectric instruments, and optical pyrometers. Chapter 4 contains data on the applications, care, and maintenance of thermocouples, radiation units, photoelectric cells, optical pyrometers, millivoltmeters and potentiometers, and a brief glossary of automatic-control terminology. The final sections of the book are composed of a short list of references; an appendix giving degrees-to-millivolt conversions for copper-constantan, iron-constantan, chromel-alumel, platinum-platinum + 10 per cent rhodium, and platinum-platinum + 13 per cent rhodium, and a table for conversion of centigrade and Fahrenheit scales; and a brief subject index.

### MACHINE ELEMENTS

**Design Data Sheets: Design of Helical Compression Springs.** Gt. Brit., Ministry of Supply, Armament Design Establishment. London, H. M. Stationery Office; New York, British Information Services, 1951. 74 pp., diagrs., figs. $1.25.

These data sheets are based largely on original theoretical and experimental work done at the National Physical Laboratory. Design Data Sheet DE 5, The Buckling of Helical Springs of Circular and Rectangular Section, follows recent work by J. A. Haringx of Philips Research Laboratories, Eindhoven, Netherlands. Each sheet contains notes on design properties, application, and manufacture; nomograms and explanatory materials; curves; and tables.

Contents: DE 1, Basic Formulae and Selection of Spring Dimensions. DE 2, Materials, Permissible Stresses, Scragging and Shot-Peening. DE 3, Relative Efficiencies of Circular and Rectangular Sections. DE 4, Dynamic Loading of Helical Compression Springs. DE 5, The Buckling of Helical Springs of Circular and Rectangular Section.

**Gauging and Measuring Screw Threads.** National Physical Laboratory. (Notes on Applied Science, No. 1.) London, H. M. Stationery Office; New York, British Information Services, 1951. 109 pp., illus., diagrs., figs. $1.25.

The sections relating to measurement are intended to refer to screw gages, but similar methods of measurement are applicable to screw threads on components, should it be necessary to measure

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rather than to gage them. The measuring instruments of N.P.L. design described are, for the most part, obtainable commercially. In addition to a list of publications given in the Appendix, there are some footnote references, mostly to N.P.L. and British Standards Institution material.

Contents: Chapter 1—1, General Definitions Relating to Screw Threads; 2, Definitions Relating to Parallel Screw Threads; 3, Taper Screw Threads; 4, Screw Thread Symbols. Chapter 2, Gauging Parallel Screw Threads. Chapter 3, Errors of Screw Threads. Chapter 4, Control of Accuracy of Pitch. Chapter 5, Hardness of Screw Gauges. Chapter 6, Mechanical Measurements of Parallel Screw Plug Gauges. Chapter 7, Formulae and Corrections for Use in the Measurement of the Effective Diameter of Parallel Screw Plug Gauges by Means of Small Cylinders. Chapter 8, Mechanical Measurements of Parallel Screw Ring Gauges. Chapter 9, Inspection of Parallel Screw Ring Gauges with Check Plugs. Chapter 10, Testing of Screw Calliper Gauges. Chapter 11, Optical Projection Apparatus. Chapter 12, Taper Screw Threads. Chapter 13, Gauging Taper Screw Threads. Chapter 14, Mechanical Measurement of Taper Screw Plug Gauges. Chapter 15, Inspection of Taper Screw Ring Gauges with Check Plugs. Chapter 16, Mechanical Measurements of Taper Screw Ring Gauges.

Appendixes: 1, Screw Thread Symbols. 2, Particulars of Standard Screw Threads. 3, Tables Showing Virtual Difference in Effective Diameter Corresponding to Errors in Pitch and Angle. 4, Sizes of Cylinders for Effective Diameter Measurements. 5, Dimensions of Vee-Pieces for Minor Diameter Measurements. 6, Tables Showing Nominal Pitches in Inches of B.A. and Metric Screws. 7, Gauging System for British Standard Pipe Threads (Taper) made to *B.S. 21: 1938*. 8, Dimensions of Fixed Taper Blocks for Measurement of Taper Screw Plug Gauges. 9, Bibliography.

## MATERIALS

**Handbook of Dangerous Materials.** N. Irving Sax. Assisted by M. J. O'Herin and W. W. Schultz. New York, Reinhold Publishing Corporation, 1951. 878 pp., diagrs., figs. $15.

Some 5,000 dangerous materials are listed in Section 1, which comprises approximately half of the book. The information given for each material consists of the hazardous properties (flammability and toxicity), treatment, antidotes, extinguishers, storage and handling, personnel safety precautions, physical properties (flash point, autoignition point, etc.), description, shipping regulations, and labeling instructions. Empiric formulas, molecular weights, taste, odor, and appearance, as well as other physical and chemical data, are included whenever available. The materials are cross-referenced and indexed. Section 2, Explosives, discusses surface storage, destruction, chemical ammunition and miscellaneous explosives, and high and low explosives. Sections 3 and 4 treat in detail fungus diseases and fungicides, and radiation and radiation hazards. Section 5 contains the complete text of the I.C.C. Shipping Tariff as issued by the Bureau of Explosives. This tariff gives detailed instruments for labeling, packaging, storage, and shipping. A list of references is given for each section. There is a list of symbols and abbreviations, and a 24-page general index. The authors are associated with the General Electric Company.

## PRODUCTION

**Resistance Welding Data Book; Theory and Practice.** 4th Ed. Indianapolis, P. R Mallory & Company, Inc., 1951. 510 pp., illus., diagrs., figs. $3.00.

The *Resistance Welding Data Book* has been prepared as a comprehensive treatise for welding engineers, plant operating executives, and practical shop men. The metallurgy, equipment, techniques, and procedures pertaining to the various types of resistance welding are presented in detailed fashion and further explained by the use of photographs, diagrams, tables, and charts. The final sections of the book contain a bibliography of

80 references, a useful appendix of tables and technical data, and an index to subjects.

Contents: Section 1—Fundamentals of Resistance Welding: Spot Welding, Projection Welding, Seam Welding, Flash and Upset Butt Welding, Butt Seam Welding, Electro-Forging and Upsetting, Electro-Brazing, Special Processes and Techniques, Lower Power Demand Resistance Welders. Section 2—Resistance Welding Controls and Equipment: Control of the Welding Current Magnitude, Switching Devices, Current Timing Controls, Sequence-Weld and Sequence Timers, Pressure Controls, Power Supply. Section 3—Materials To Be Welded: Low Carbon Steel, Medium and High Carbon Plain Steel, Low and Medium Alloy Steels, High Alloy Steels (Stainless Steels) Coated Steels, Aluminum Alloys, Copper and Copper Base Alloys, Magnesium and Its Alloys, Nickel and Nickel Alloys, Tungsten, Molybdenum and Tantalum, Spot Welding Dissimilar Metals. Section 4—Alloys for Resistance Welding Applications: The Mallory Alloys and Elkonites; Group A, The Copper Base Alloys; Group B, The Elkonite Metals. Section 5—Resistance Welding Electrodes, Dies and Holders: Functions of Resistance Welding Electrodes, General Causes and Prevention of Electrode Deterioration, Electrode Requirements, Electrode Cooling Requirements, Types and Designs of Electrodes. Section 6—The Silver Brazing of Elkonites to Mallory Copper Base Alloys for Resistance Welding Applications: The Silver Brazing of New Parts, Heat Treatment of Copper Base Alloys Prior to Re-Brazing of New Elkonite Facing. Section 7—Recommended Practices for Resistance Welding: Spot and Seam Welding, Projection Welding, Flash Welding, Standard Methods for Testing Resistance Welds. Section 8—Miscellaneous Tables and Data: Recommended Maintenance Practices for Resistance Welding Machines, Do's and Don't's for Resistance Welding Engineers, Resistance Welding Definitions (R.W.M.A.), Physical Properties of Metals, Relationships Between Hardness Values, Weight of Rods, Areas of Circles, Metric Equivalents, Temperature Conversion Tables, Comparison of Gauges, Metric and Decimal Equivalents of Common Fractions, Morse Tapers, Physical and Mechanical Properties of Silver Elkonite.

**Industrial Furnaces, Vol. 1.** W. Trinks. 4th Ed. New York, John Wiley & Sons, Inc., 1951. 526 pp., illus., diagrs., figs. $10.

The term, "industrial furnaces," as used in this book, includes only those furnaces in which heat is imparted for the purpose of raising temperature and in which no chemical changes, or changes of state such as melting or vaporization, are intended to take place. The general arrangement of the subject matter follows that of the previous, 1934, edition with the exception that infrequently used material has been moved to the appendix. About 40 per cent of the text has been rewritten, and the book contains 94 new illustrations. Tables have been brought up to date. Calculations and tabular data have been changed from gross tons to net tons, in accordance with prevalent custom. There are many worked examples in the text, some footnote references, and a 12-page index of topics. The author is Professor Emeritus of Mechanical Engineering, Carnegie Institute of Technology.

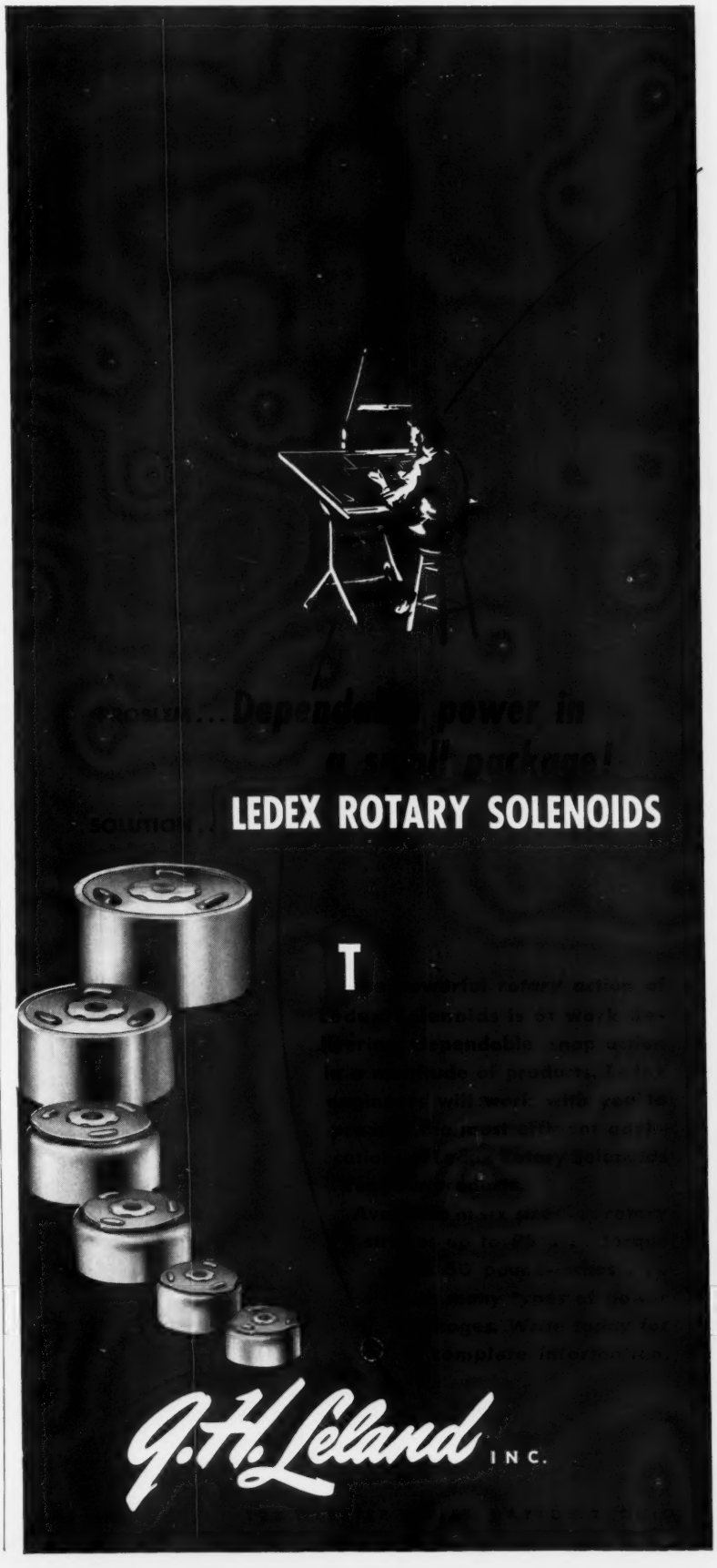
Contents: Chapter (1) Introduction. Chapter (2) The Heating Capacity of Furnaces. Chapter (3) The Fuel Economy of Furnaces. Chapter (4) Heat-Saving Appliances with Particular Reference to Industrial Furnaces. Chapter (5) Strength and Durability of Furnaces. Chapter (6) Movement of Gases in Furnaces. Appendices.

## REFERENCE WORKS

*YEARBOOKS*

**Jane's All the World's Aircraft, 1951–52.** Compiled and Edited by Leonard Bridgman. New York, McGraw-Hill Book Company, Inc., 1951. 468 pp., illus., diagrs. $22.50.

As in the past, *Jane's* stands as a useful and well-nigh indispensable volume for those who must keep at their finger tips a mass of accurate



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information on the world's aircraft, power plants, and military and civil air fleets. For this edition, following customary practice, all type matter has been reset, and nearly 850 illustrations have been introduced, 472 of which are new. Sections A and B, which cover the military and civilian aviation activities of all countries and territories, have been checked against authoritative sources for new information. Section C, which covers the aircraft industry and its products, now comprises 293 pages and contains 718 illustrations, 440 of which are new. A useful feature retained in this edition is the aircraft index in Section C, which greatly eases the task of locating data on one of several hundred aircraft when only a model number, or perhaps only a picturesque designation, comes to mind. The sparsity of material on Soviet aircraft is due to the omission of all but confirmed data. The sections on power plants reflect the growing emphasis on turbine engines. The section on airships is substantially unchanged from last year. Principal world records are listed, and a chronology of important first flights made from June 1, 1950, to May 31, 1951, has been added. A brief supplement is also included which gives information on aircraft and engines which became available from the time the main book went to press until September 30, 1951.

## SCIENCES, GENERAL

### *MATHEMATICS*

**An Introduction to the Calculus of Variations.** Charles Fox. London, New York, Oxford University Press, 1950. 271 pp., figs. $5.00.

The calculus of variations is developed both for its own intrinsic interest and because of its wide and powerful applications to modern mathematical physics. The discussion of the first and second variation of an integral is illustrated by applications of the principle of least action to dynamic problems. One chapter, which deals with methods of approximations such as the Rayleigh-Ritz method, is illustrated by applications to the theory of elasticity. The contents include a study of isoperimetrical problems and an account of Weierstrass' theory of strong variations which is based upon the work of Hilbert. Also given are a proof of Hamilton's principle and an account of the way this can be used to deal with dynamic problems in the special theory of relativity. The work is within the scope of honors students in mathematics and physics.

Contents: (1) The First Variation. (2) The Second Variation. (3) Generalizations of the Results of the Previous Chapters. (4) Relative Maxima and Minima and Isoperimetrical Problems. (5) Hamilton's Principle and the Principle of Least Action. (6) Hamilton's Principle in the Special Theory of Relativity. (7) Approximation Methods with Applications to Problems of Elasticity. (8) Integrals with Variable End Points, Hilbert's Integral. (9) Strong Variations and the Weierstrassian $E$ Function.

**Tensor Analysis; Theory and Applications.** I. S. Sokolnikoff. New York, John Wiley & Sons, Inc., 1951. 335 pp., figs. $6.00.

The book is an outgrowth of a course of lectures given to graduate students by the author, who is Professor of Mathematics, University of California, Los Angeles. The first chapter is devoted to linear transformations and matrices, with stress being placed on the geometry and physics of the situation. Algebra and calculus of tensors are taken up in the second chapter. The treatment here is self-contained and is not made to depend on some special field of mathematics, such as geometry or relativity, as a medium for the development of tensor analysis. Chapter 3 contains a selection of geometric topics important in the study of analytic dynamics and in such portions of elasticity and plasticity as deal with the deformation of plates and shells; this chapter provides an introduction to metric differential geometry. The essential concepts of analytic mechanics are presented in Chapter 4. A brief treatment of relativistic mechanics is contained in Chapter 5. The final chapter is concerned with a formulation of the essential ideas of nonlinear mechanics of continuous media in the most general tensor form. The classical linearized equations of elasticity and fluid mechanics appear as special cases of the general treatment. A list of books for further consultation, problems to be worked out, and footnote references have been provided for the reader or student.

**Graphic Aids in Engineering Computation.** Randolph P. Hoelscher, Joseph Norman Arnold, and Stanley H. Pierce. New York, McGraw-Hill Book Company, Inc., 1952. 197 pp., figs. $4.50.

This college textbook contains chapters on standard slide rules, derivation of empiric equations from engineering data, alignment charts, graphic calculus, alignment charts with determinants, special slide rules, and movable-scale nomographs. The treatment is designed for students who have completed analytic geometry and provides numerous examples and exercises. Professors Hoelscher and Pierce are with the University of Illinois; Professor Arnold, whose mimeographed lecture notes were the foundation for this book, is with Purdue University.

## STRUCTURES

**Buckling Strength of Metal Structures.** Friedrich Bleich. With the Collaboration of Lyle B. Ramsey. Edited by Hans H. Bleich. New York, McGraw-Hill Book Company, Inc., 1952. 508 pp., diagrs., figs. $10.

This volume in the Engineering Societies Monograph series presents data on the behavior of fabricated steel structures under compression loading. The book is the outcome of a study of all available literature on the subject; to the results of this study has been added much of the author's original work. Associated in the work were the David Taylor Model Basin of the Navy Bureau of Ships and the Column Research Council.

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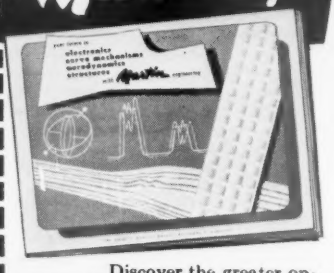

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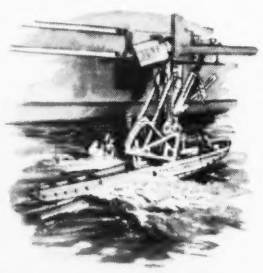

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**Simplified Mechanics and Strength of Materials.** Harry Parker. New York, John Wiley & Sons, Inc., 1951. 275 pp., figs. $4.00.

An elementary treatise for classroom and home-study use. A working knowledge of algebra and arithmetic comprise the mathematical prerequisites. The author, associated with the University of Pennsylvania, has explained the illustrative examples in detail and provided problems to be solved by the student. Tables of stresses, properties, and other engineering data are given in the text.

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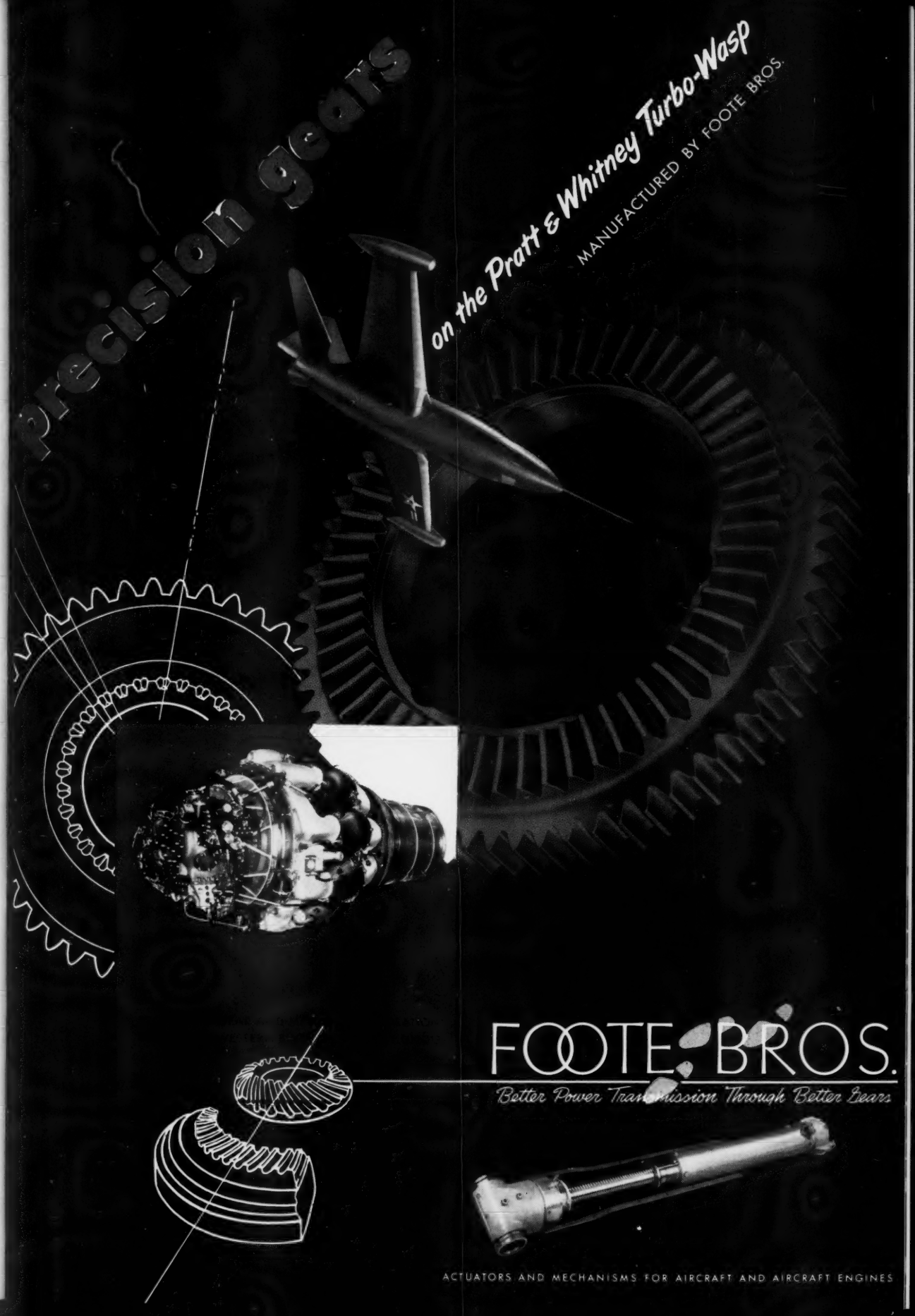
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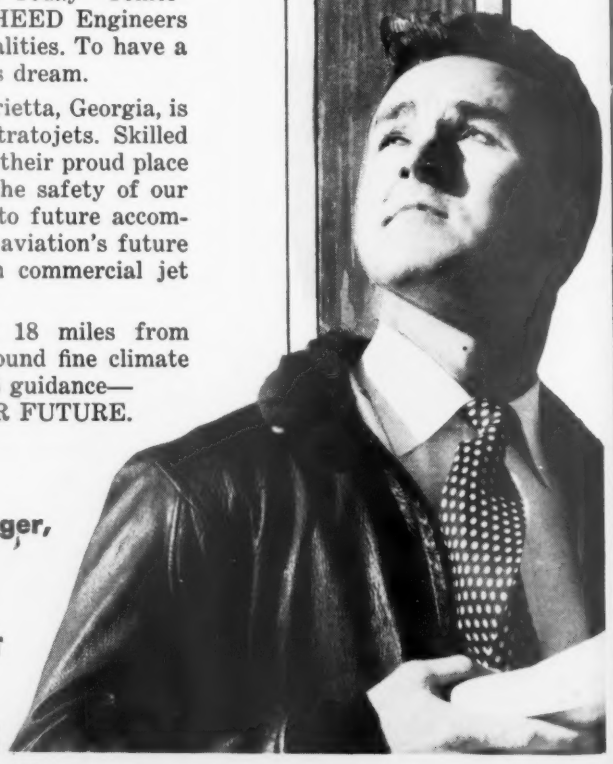

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